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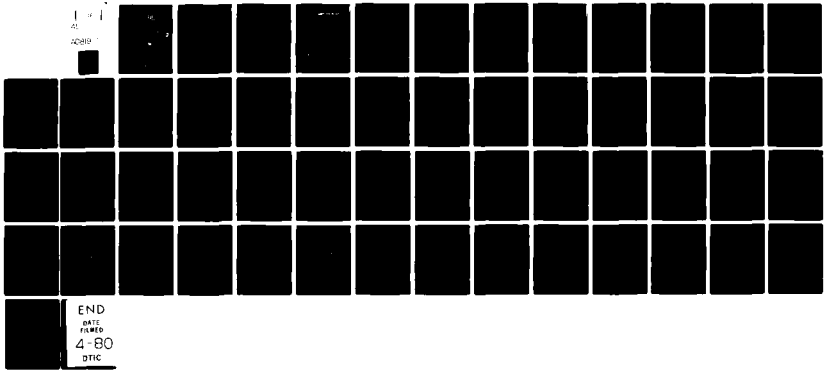

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, member of the

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NEWS & NOTES

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CHEMISTRY

CALORIMETRY AND THERMAL ANALYSIS, A MICROSYMPOSIUM AT MACRO

The practitioners of adiabatic calorimetry have in the past looked with disdain on those people who engage in what is generally called thermal analysis. After all, the calorimetrists can measure enthalpy (heat content), and enthalpy changes such as the heat of fusion, quantitatively and with great precision; whereas classical differential thermal analysis can at best determine the temperature of transitions and approximate estimates of enthalpic changes. However, all this has changed in recent years with the development of the differential scanning calorimeters (DSC), which measure the energy input into a sample relative to some reference material rather than just the temperature difference. The essential principle of DSC is that one increases the electrical energy necessary to keep a sample at constant temperature or at a constant rate of temperature change relative to a reference cell. This energy is directly proportional to the enthalpy change. Compared to the calorimeters, DSC's require much less insulation and temperature controls, and the sample size can be quite small (~10 mgm). In principle, adiabatic calorimetry is somewhat more accurate than DSC.

The disapproval by the adiabatic calorimetrists of the thermal analysis types has all but disappeared, and it was difficult to distinguish one from the other at the meeting on Microcalorimetry of Macromolecules (20th Prague Microsymposium on Macromolecules) held on 16-19 July 1979, at the Institute of Macromolecular Chemistry, Prague, Czechoslovakia (the Institute likes to refer to itself as MACRO Praha). The meeting was anything but "micro", with 6 invited lectures, 4 panel discussions, and 36 poster presentations. There were about 110 attendees from 18 countries, including the US, Canada, UK, Western and Eastern Europe, India, USSR, and even one from Nigeria. MACRO is very well equipped for presenting these symposia. In addition to an excellently designed lecture hall and projection system, closed-circuit television transmits from the lecture room to a comfortable lounge where a participant may view the proceedings in armchair comfort. Also, they had an effective method of breaking up small group conversations in the hallways and getting the audience into the lecture hall. A bit of Wagnarian music was broadcast from the loudspeaker system, softly at first, but reaching a level that made conversation impossible. No one was in doubt that the lecture was about to resume.

The first invited lecture was given by Dr. D. Patterson (McGill Univ., Montreal) who described his work on molecular order in liquid hydrocarbons—specifically the normal alkanes with 16 or more carbon atoms. There is evidence of short-range order in these compounds in the liquid state, i.e., small clusters in which the molecules are oriented parallel to one another. This organization is evidenced by a slight increase in the heat of vaporization. It is much more evident, as Patterson showed, in the heat of mixing of the alkanes with "globular" shaped molecules such as cylohexane. Upon mixing equimolar amounts of cyclohexane with the C_{16}-alkane, there is a positive heat of mixing (ΔH_m) of about 300 J/mole. The Prigogine-Flory theory, which ignores any ordering of the liquid, predicts a much smaller ΔH_m. As might be expected, this ΔH_m decreases with increasing temperature, since chain orientation should decrease with temperature. The short-chain hydrocarbons, e.g., the C_6 n-alkane, which do not have any short-range order, have the same effect as cyclohexane when mixed with the C_{16} alkane. Patterson concludes that the short-range order in the longer alkanes comes about not because of their longer chain length compared to the shorter homologs, but because of a lower free volume at a given temperature.

The n-alkanes even with 16 C-atoms can hardly be called macromolecules. However, short-range order probably exists in polyolefin solutions and melts, and so studies like those of Patterson are thought to be pertinent to their molecular organization.

Polymer calorimetry was the subject of Dr. F.E. Karasz's (Univ. of Massachusetts, Amherst) lecture in which he discussed their heat of mixing. Because of the high viscosity of polymers, it is rarely possible

to measure ΔH_m directly, even in the molten state. Instead, the heats of solution of the individual polymers and of the blend in a common solvent are measured and then, using the principle that the enthalpy of a state is independent of the path by which that state is reached, one can calculate the heat of mixing. However, in solution the polymer is in a "liquid" state, whereas at the temperature at which the ΔH_m is being sought the polymer is likely to be a solid. As a result the measured ΔH_m is for the polymer in a rather hypothetical condition. Even so, Karasz finds that the procedure can be used advantageously by measuring ΔH_m as a function of temperature to reveal regions of compatibility which would otherwise be experimentally inaccessable. He described a study of polyphenylene oxides mixed with various fluorosubstituted polystyrenes that are generally immiscible, but he finds a narrow range of concentrations where they are compatible.

Dr. B. Wunderlich (Rensselaer Polytechnic Inst., Troy, NY) gave an overview of his extensive work on the calorimetry of linear macromolecules. For more than a decade he has used both adiabatic calorimetry and DSC to determine the heat capacities of polymers. He concludes that at this point in time, although adiabatic measurements are more precise, the DSC is the method of choice. The calorimeters can give precisions of ±1.0%, but the repeatability between laboratories and the variation in the polymer samples themselves result in accuracies no better than ±3%, which the better DSC instruments can easily match. Moreover, scanning calorimetry is faster, easier to perform, and more amenable to computer control than adiabatic calorimetry. Wunderlich has assembled both his own and literature data on the specific heat and phase transitions of linear polymers, and is subjecting the data to critical analysis which is published in appropriate journals. He is also establishing relationships between molecular structure and heat capacity. He finds that for linear macromolecules in the solid state, all of the vibrational contributions to the specific heat except intermolecular skeletal vibrations are additive according to the chemical structure. The skeletal vibrations are few and affect the heat capacity only up to 50 K. The chemical additivity for the heat capacity of polymeric liquids is more difficult, because of potential-energy contributions which are only partly due to intermolecular effects.

Dr. H. Baur (BASF Aktiengesellschaft, Ludwigshafen/Rhein, FRG) discussed the theoretical aspects of the melting of polymer crystals. He noted that it is commonly assumed that the partially crystalline state can be regarded as a two-phase system and melting as a first-order transition. However, Baur pointed out that if the chain molecules traverse both phases then the phases are not independent, negating one of the preconditions of the normal theory of melting. If the phases are not independent, then the Gibbs free energy should be a nonlinear function of the degree of crystallinity, and Baur went through the thermodynamic analysis to show that such was the case. He went on to conjecture that if the tie molecules between phases predominate, then the equilibrium melting is a diffuse transition; but if loops predominate, melting is a first-order transition.

Differential scanning calorimetry can be used to study biochemical processes such as the helix-coil transition of polypeptides and nucleic acids, RNA unfolding, and the gel-liquid transitions of bilayers. The small sample requirements of modern DSC equipment make them ideal for studying these expensive biomaterials. Dr. R.L. Biltonen (Univ. of Virginia School of Medicine, Charlottesville) presented a lecture on the statistical mechanical thermodynamic analysis of DSC data for biochemical transitions. He developed the partition function for two-state reactions, and then showed how the analysis can be reformulated so that complex heat capacity data from multitransition processes can be deconvolved. In a poster presentation, Biltonen (with Dr. E. Freire) demonstrated the application of the deconvolution theory to the gel-liquid crystalline transition of phospholipid bilayer membranes.

Calorimetry is used to investigate colloidal systems such as micelle formation and solubilization in microemulsions. Dr. J.E. Desnoyers (Univ. de Sherbrooke, Sherbrooke, Quebec) described his work on the micelles and microemulsions formed by various nonionic, anionic, and cationic surfactants in aqueous solution.

Two of the invited lectures were essentially devoted to calorimetric instrumentation. Dr. I. Wadso (Univ. of Lund, Lund, Sweden) presented a survey of calorimeters (mostly adiabatic) that can be used to study biopolymers. These included instruments for heats of solution, mixing, dilution, and vaporization. He made the point that if simple organic compounds are used to model biopolymers, the models can often be put through thermodynamically interesting transitions such as vaporization from which the biopolymers themselves would not survive.

Dr. P.L. Privalov (Inst. of Protein Research, Acad. of Sci., Poustchino, USSR) reviewed the principles of DSC and the techniques of data analysis. He also presented a critical analysis of the operating characteristics of most of the commercially available instruments and ways they can be modified for better performance.

In the poster session, almost half of the presentations were on biomaterials and biochemical systems. Among these, the poster by Dr. F. Franks (Cambridge Univ., UK) was of special interest to this author. Franks is investigating the phenomena associated with the cryofixation of biological specimens. Freezing occurs so rapidly that the tissues are preserved in a solid, hydrated form, without the formation of ice crystals which would rupture the tissue. He is studying rapidly quenched solutions of hydro phillic polymers by observing the transitions in DSC heating scans. Above a certain concentration of polymer, the DSC transition for ice recrystallization or melting disappears, which he interprets to mean that all of the water is bound to the polymer with none of it acting as a simple solvent. The number of water molecules bound to each monomer unit depends on the polymer. The association number varied from 4.6 for hydroxyethyl starch to 2 for polyethylene glycol. Examination of the frozen materials using freeze fracture electron microscopy revealed the absence of any ice structure in the materials with high polymer content. Instead, there were closely packed microspheres with radii of about 100 Å which Franks suggests are aggregates of hydrated polymer. (Willard D. Bascom)

CHEMISTRY IN SCANDINAVIA

Bergen

The Chemistry Department of the University of Bergen in Norway shares a very large new building in the center of the city with the departments of geology, biology and seismology. The Department has four professors, one of whom serves as chairman for a two-year term. The present incumbents are Prof. R.E. Manne (theoretical chemistry), Prof. O. Foss (inorganic chemistry, mainly sulphur compounds), Prof. Sletten (physical chemistry, X-ray crystallography) and Prof. G. Aksnes (organic chemistry, mainly organic phosphorus compounds). It should be noted that Aksnes has recently become interested in the oxidation of organic compounds by means of singlet oxygen, with a view toward cleanup of oil spills from ocean surfaces. A recent paper by Aksnes on "Photooxidation of Aromatic Compounds in the Two-Phase system: Hydrocarbon/Water" dealing with 9, 10-dimethylanthracene recently appeared in *Acta Chemica Scandinavica* and may well be relevant to the decontamination problem. The Department is very well equipped with respect to instrumentation including a self-contained x-ray diffractometer with computer, Fourier transform ir, and a variety of conventional ir uv, NMR, and mass spectrometers.

The host for my visit to the Department was Dr. Jon Songstad, one of the junior faculty members in inorganic chemistry. Songstad is primarily interested in the behavior of chemical reactions in solution and the systems that he has been studying have been on the borderline between organic and inorganic chemistry. Thus, about four years ago he carried out an in-depth study of a variety of bis(triphenylphosphine)-iminium (PNP) salts. These compounds are relatively easily synthesized from triphenylphosphine and show remarkable stability, coupled with solubility in organic solvents [*Acta Chemica Scandinavica* A31, 645 (1977)]. Related to this work is Songstad's interest in phosphines containing three organic amino groups on the phosphorus atom. Along these lines he has studied the morpholino- and the piperidino- derivatives, including a determination of their molecular structures by means of x-ray diffraction

(in collaboration with Dr. Romming at the University of Oslo). These compounds are strong nucleophiles and the x-ray work indicates that only one of the N-atoms is tetrahedral; he believes that this N-atom is the reactive center in the molecule. In his recent work he has been exchanging some of the more conventional anions of these salts with such unusual anions as thiocyanate and tellurocyanate. In addition to this synthetic work, Songstad is also interested in studying the kinetics of some acid-base reactions by the stopped-flow technique. He has been evaluating the effect of substituents on the reactions of benzyltrialkyl phosphonium salts with bases in acetonitrile and acetone as solvents. Another reaction he is interested in is the reaction of cyanide ion with tetrathionate. Songstad was kind enough to introduce me to his colleague, Dr. H. Hoiland, whose main research interest is in the field of micelles and with whom he has been collaborating ever since they found out that some of Songstad's PNP salts had detergent properties. Hoiland's research concerns the thermodynamics of micelle formation and he has been studying the volume changes involved in the solubilization of micelles by means of the high-sensitivity balance developed in Prof. Kratky's Institute in Graz (Austria). In addition to measurements of partial molal volumes, they have also been studying compressibilities. In order to determine the latter, they have developed a technique for measuring conductances under high pressures (2-3 kbars).

Stockholm

Prof. Gunnar Wettermark, who holds the chair of physical chemistry at the Royal Institute of Technology, Stockholm, Sweden has some very unusual qualifications. In the first place, for about 5 years he headed the physical chemistry section at NARADCOM (US Army, Natick, MA) and made important contributions to their program in photochemistry; he left Natick a little over 10 years ago to enter medical school and received his M.D. from the University of Uppsala in the early 70's. In Stockholm he was at first involved in continuing research in photochemistry and, parallel to this, he carried out some work in the field of photobiology. However, a few years ago Wettermark, along with a number of other Swedish scientists, were included in the government-sponsored Energy Storage Research Project and it was decided that the group in Stockholm would concentrate on the thermal aspects of the energy problem and leave photochemical research to the physical chemists at Uppsala. A summary of much of their work (and thinking) in this area appeared in a monograph recently with a title "Storage of Heat—A Survey of Efforts and Possibilities" which was published by the Swedish Council for Building Research. Since assuming his position in Stockholm, Wettermark has become interested in the phenomenon of chemiluminescence, particularly with respect to its analytical applications. In this work he found that they could bridge the fields of chemistry and biology and apply this highly sensitive analytical technique to both chemical reactions and living systems. The Institute of Physical Chemistry is housed in an older building on the main campus of the Royal Institute, not far from the center of Stockholm. There are at present around 30 people involved in research, 10 of whom are working on thermal energy storage. The instrumentation is very good; it includes a variety of spectrometers including high-resolution NMR and a Shimadzu uv instrument that is equipped with a microscope attachment for studies of single cells. In addition, one of the laboratories is equipped for microwave spectroscopy, where Dr. Ljungren is studying such aromatic compounds as styrene, difluorobenzene and some small unsaturated heterocyclic molecules.

Uppsala

Some time ago Prof. Stig Claesson (who has been Prof. of Physical Chemistry at Uppsala for more than two decades) invited me to present a seminar. Unfortunately, on the day of my visit, Claesson was ill and in his absence Dr. Lars Tegner acted as my host. Research in Uppsala is still concentrated in the same two areas that have been of interest to Claesson for a long time: research related to ph photochemistry and research on polymers. Since Claesson has long been involved with the National Research Councils in Sweden, it is not surprising that their work in photochemistry has, during the past five to six years, been related to the photochemical conversion and storage of solar energy. (This work is being done under the

auspices of the National Swedish Board for Energy Source Development.) In our discussions I got the impression from Tegner that, while the research in photochemistry has been turned over to the other people in the Institute, Claesson personally oversees the research in the polymer area. My seminar and a tour of the laboratories took up most of my time in Uppsala, hence we had little time to discuss details of their current research activities. Nonetheless they have a continued interest in photochromism and in photochemical cis-trans isomerization.

Prof. Claesson has long been known as a chemist who is very devoted to the development of instrumentation. Although the world's most powerful conventional photolysis unit has now been retired, there is much else to take its place. In the photochemistry area they have a variety of lasers available for both pulsed and CW operation, they are equipped to measure spectra under pressure (up to 10 kbars), and they can measure the fluorescence and the fluorescence depolarization of polymers. Also there is instrumentation for dynamic light-scattering of polymers and for relaxation measurements on polymers by interferometric techniques with psec time resolution. The Institute is in the same building where it has been for several decades, but the interior is well maintained and has good facilities.

Gothenburg

The Chemistry Laboratories in the Chalmers Institute of Technology of Gothenburg University were in the midst of being remodeled at the time of my visit but I came away with the distinct impression that once the job is finished (probably within the next six months) the staff and students will have very fine laboratory space available to them. My host was Dr. H.D. Becker, a German-born and German-educated organic photochemist who came to Gothenburg by way of GE-Schenectady about seven years ago. Becker's research interests center about the very important question of correlation between fluorescence and the molecular geometry of organic molecules. For these studies he has synthesized a number of interesting anthracene derivatives, studied their fluorescence and, in collaboration with a research group in Australia, determined their crystal structures. In several instances they find that the luminescence results from an exciplex (excited state complex). In addition, they have also been involved in studying the effect of substituents on some iso-oxindigos, and, again in collaboration with the group in Australia, find that the introduction of certain substituents will cause a twisting of the central part of the molecule.

Becker introduced me to two of his colleagues, Dr. J.E. Löfroth and Dr. M. Almgren. Löfroth is a physical chemist who is interested in polarized fluorescence, photoconductivity of polymers and the determination of excited state lifetimes by means of a very sensitive single-photon counting apparatus.

Almgren has long been active in the field of micelles. His current research concerns the photochemistry of micelle systems, including studies of photoinduced electron-transfer processes. He is also interested in the solubilization process. Currently they are studying negative ions solubilization in negatively charged micelles and the kinetics of the diffusion processes within micelle systems. Some of the molecules of interest to them are suitably substituted anthraquinone and duroquinone sulfonates and also ruthenium trisbipyridyl. In their flourescence-quenching studies they have been using 9-methylanthracene as a quencher.

Lund

Although Lund was the smallest city on my itinerary it not only has the largest chemistry building, but the new 300,000 ft^2 Chemical Center of the University of Lund may well be the largest of its kind in the world. My host, Prof. Stig Sunner, is being credited with being the sparkplug behind getting the University and the Swedish Government to construct this facility. It should also be mentioned that, when the building was completed a little over ten years ago, it was built with an expectation of continually increasing enrollments in chemistry, an expectation that has not been fulfilled. As a result, the building is not being used to capacity.

Sunner provided me with a brief overview of the activities in the center. In the field of physical chemistry the emphasis is on studies on membranes, including relaxation proc-

esses. Prof. Mosbach (biochemical engineering) is interested in the related area of enzymes including matrix-bound enzymes. There are four professors in the areas of food technology/food chemistry whose primary interest is in the basic processes involved in the preparation of foods. In the field of inorganic chemistry the primary topic of interest has been coordination chemistry; however this is changing now in emphasis towards the biophysical aspects. Lund has long had a tradition of research in thermochemistry by Sunner for more than three decades and now his long-time collaborator, I. Wadso, also holds a Professorship in this area. Wadso's interests concern instrumental development (primarily for microcalorimetry) and research in the calorimetry of biological processes (*ESN* 34-1:547). In this work he is studying blood, fat and muscle cells and is monitoring biological processes by calorimetry. In addition, they are also studying simpler organic prototype molecules.

Most of the research in thermochemistry at Lund is under the direction of Sunner. He pointed out to me that they now have a unique capability of doing calorimetry at very low pressures (ca. 0.0001 mm) and he gave the US Army credit for having supported the original research 20 years ago that led to this development. They are interested in determining enthalpies of formation for organic compounds with high precision, since this is important in determining the strength of bonds in molecules. In addition they are measuring enthalpies of combustion and enthalpies of vaporization. Sunner pointed out that the literature values for vaporization data have frequently been found to be wrong. They have also been involved in calorimetric measurements of phase transitions and heat capacities to temperatures as low as 4 K. In their research they are particularly interested in determining correlations between chemical structure and enthalpies of combustion for organic compounds. They find that compounds containing more than one oxygen atom show an abnormal enthalpy of combustion; similarly they find that the incremental changes in ΔH as the chain length increases are different for alcohols than for alkanes. In general, they have been successful in reducing the sample size requirements to 0.2g. Sunner also mentioned that there are very few good measurements available for boranes.

Prof. S. Gronowitz is the senior professor of organic chemistry at this Center. His research interests deal primarily with heterocyclic compounds and he and his students have been studying thiophene- and selenophene-rings that are fused (in pairs) to a central alicyclic ring system. These compounds can be readily made from the organolithium derivatives of the individual rings. They have succeeded in observing optical activity in such ring systems when suitable substituents are introduced that cause deviation from coplanarity. In their synthetic work they have also fused thiophene to borazarobenzene and find that such fused bicyclics behave like aromatic systems. In a somewhat different area, they have been studying the optical rotatory dispersion of optically active triglycerides in the vacuum uv. Prof. Gronowitz has excellent instrumentation available for his research, but he was very outspoken in his complaints about the lack of graduate students. During the last 8 years his research group has dropped in size from 35 to 8 and by next year he will probably have no more than 3-4 graduate students!

Copenhagen

Much has changed since my last visit to the Danish Institute of Technology some 20 years ago. In the first place, in 1966 the Institute moved from its old location in the center of the city to suburban Lyngby. In the second place, my host Prof. Flemming Woldbye, who was at that time a promising young faculty member, is now a former Rector of the Institute and is at present Chairman of the Danish Council for Science Policy and Planning which is the principal science-advisory body to the Danish Government. Although the Council now reports to the Government through the Minister of Education, Woldbye told me that he expected this to change and that they will soon have access to other Ministers who are involved in science and technology.

Woldbye took time off from his busy schedule to fill me in briefly on current activities in Chemistry Laboratory A of the Institute (combined inorganic and analytical chemistry). As usual with most university constructions that took place in the 60s, the buildings were planned with future expansion in mind which has not

materialized. Furthermore, because universities in Denmark are no longer run by the faculty, but by committees consisting of faculty, non-faculty employees, and students, the extent of laboratory instruction has been reduced considerably at the students' insistence. As a result, the number of faculty positions has now been reduced to 20 (from an initial 30) and the very fine teaching laboratories are getting little use. There are 5 graduate students in Chemistry Laboratory A and 120-140 in the Institute as a whole.

In addition to Woldbye, there are two professors in the laboratory: Hofmann-Bang (who has been at the Institute for 3 decades) and Ruzicka (a Czech refugee who happened to be a visiting scholar at the Institute in 1968 and who elected to remain in Denmark when the tanks moved into Prague). Ruzicka's research interests are in the field of analytical chemistry, including electrochemical and stopped-flow techniques. Dr. Rasmussen is involved in theoretical calculations on molecular structure and the correlation of vibrational spectra with structure. He is interested in coordination complexes, lipids and carbohydrates.

Another theoretician in the Laboratory is Dr. Ulstrup, who is interested in developing correlations transfer reactions. Dr. W. J. Bjerrum, son and grandson of the famous Danish chemists, has a small but active research group working on molten salts. They are particularly interested in the mixtures of sulphates that are present in mixed potassium and vanadium sulphate and are using EMF, cryoscopy and a variety of spectroscopic techniques in their studies. Another system of practical importance that they have been involved with are the mixed chlorides of lithium, potassium and aluminum, the electrolysis of which provides an alternate method for obtaining aluminum metal. They find that the chloride ion concentration can be determined conveniently by using a chlorine electrode in a manner similar to the determination of pH, using a hydrogen electrode.

Aarhus

The Chemistry Department at the University of Aarhus in the second largest city in Denmark, is housed in a large, modern building and has a faculty of around 40. There are 7 organic chemists on the faculty and my host was Prof. Henning Lund. Lund's field of interest is organic electrochemistry and he has been the chief organizer of the annual European Conferences on this topic that are held at Sandbjerg (near the German border) under the sponsorship of UNESCO. Lund is interested in studying the formation and chemical reactivity of electrogenerated radical anions. As an example he mentioned the radical anion that can be formed from pyrene and its reaction with alkyl halides that result in alkylation. Another related reaction that they have been studying involves esters of cinnamic acids; the radical ion of this compound can be acylated (in the beta-position) by means of acetic anhydride. He also finds that the radical anion formed from anthracene can be reacted with ethylene chloride to give an internally bridged tetracyclic compound with a 2-carbon bridge introduced in the 9,10-positions. The reaction of the same radical anion with propylene bromide results in some internally bridged product and also some exocyclized in the 1,2-positions. The concentrations that they use for these reactions are 0.01-0.001 M and they are very interested in studying the dependence of the reaction on the reduction potential of the starting materials. He finds that he can determine the rate constants for the various processes by varying the sweep rates. [George M. Wyman, US Army Research and Standardization Group (Europe)]

ELECTRONICS

WHAT'S NEW IN CATHODE RAY TUBE DISPLAYS?

The Vacuum and Gas-filled Devices Group of IEE, the Institution of Electrical Engineers, recently sponsored a one-day colloquium at the IEE Building in London, aimed at acquainting engineers with the latest developments in cathode ray tube displays. It was the first session on this subject held in a dozen years, despite the fact that there are at least three manufacturers of cathode ray tubes in Britain (Ferranti Computer Systems Ltd., Rank Electronic Tubes, and the M.O. Valve Company of General Electric Co.).

The organizer and chairman of the colloquium was Douglas S. Hills, Engineering Consultant at Rank Electronic Tubes. Hills has traveled extensively in the US and is known to many engineers in the US who are responsible for incorporating displays into their systems.

Among his opening remarks, Hills pointed out that despite solid-state and laser-display efforts there is true growth in the market for high-resolution cathode ray tubes (CRT). He also stated that it is difficult to recruit engineers for CRT work. Finally, he lamented the fact that only sixty people were in attendance at the colloquium, stating that if a similar meeting had been held in one of the leading cities of the US, there would be 1200 people in attendance.

The presentations covered the areas of CRT phototypesetting, computer-CRT systems, ultrahigh resolution CRT systems, color telecine (movies on TV) and flying spot tubes, interactive video displays, CRTs with multi-function color screens, and an applications talk relating to aircraft cockpits.

In the leadoff paper, J.C.A. Chaimowicz (Linotype Paul, Cheltenham, UK) described the uses of CRTs in modern phototypesetting. Here, under computer control and backed up by electronically stored typeface information, images (i.e., typed texts) are optically projected onto a web of photosensitized film or paper which, after exposure and development, becomes the printer's masters for plate making. To cope with the task of reproducing characters as small as 0.78 mm and as tall as 50 mm in a number of fonts and alphabets with sufficient detail and uniform brightness, and of X-Y location of the spot with an an accuracy of 10^{-4} of the screen diameter, the CRTs must satisfy a set of stringent, demanding specifications, be driven by sophisticated circuitry, and be combined with high quality optics. (In a typical system there are 16,185 horizontal positions on an 11-inch screen.) To satisfy the severe positioning and uniformity requirements, as many as 27 control voltages are applied to a CRT.

Chaimowicz mentioned that since much of the light of a normal CRT when focused through a lens is lost, newer, more efficient systems use a lower current CRT with a fiber optics face plate (obtained from the US), which directs the light to the CRT surface. The fibers used in such a face plate are approximately hexagonal, with dimension between parallel faces of 8 μ and a final spot diameter from each fiber of about 30 μ. (A simple calculation shows that the total length of fiber of such a face plate is about 1000 km.)

In summary, this paper demonstrated the dependence of modern printing on CRTs and that the UK and the US are at the forefront of this technology.

In a talk that covered technical details of ultrahigh resolution CRT subsystems (beam diameter of 25 μ or less), M.R. Bennett (Ferranti Computer Systems Ltd., Chadderton, Oldham, UK) stated that such subsystems are playing an increasing role in electronic equipments where "optical" scanning is required, in application, from following photographically recorded tracks of nuclear particles to actual recording on film in phototypesetters. He emphasized that it is not sufficient to deal just with the CRTs, but the complete subsystem must be considered, for to obtain the required performance, recourse has to be made to sophisticated electromagnetic deflection and focus coils, together with correction systems such as for the removal of astigmatism. According to Bennett, Ferranti's sm smallest electron beam has a 5-μ spot, but as seen on a screen it looks like 10μ, because of scattering by the glass. (The thickness of glass in his CRTs varies from 2 mm to 15 mm.)

Some other interesting statements made were: 1) All ultrahigh resolution systems use magnetic deflection, 2) For the bubble-chamber requirement, as used by CERN (Geneva), the spot drift has been limited to only a few microns over a 24-hr period. Moreover, the user knows where the spot is within one part in 20,000. 3) For ultrahigh resolution the electron gun is unusual, in that there are two cross-overs. 4) Spot drift stability requires special covering of the space with metal shields to prevent beam charging. 5) Grid emission must be prevented. 6) Phosphor screens are made either by cataphoresis or by a settling technique. 7) The term "noise" is used to refer to variations in light output because of non-uniformity in the phosphor. In phosphor deposition, a compromise must be reached between a thin phosphor, which is "noisy," and a thick one, which loses resolution. The highest resolution of Ferranti phosphors is 400 cycles per cm.

In summary, Bennett stated that in the field of ultrahigh resolution displays there is at present no competition to cathode ray tubes.

THE next two talks dealt with schemes of conversion of an image from moving picture film into television signals, i.e., how a movie is shown on TV. The first was by J.D. Millward (Rank Cintell, UK), who has the responsibility for devising and operating systems for performing the conversion process. The second, by R.G. Johnson (Rank Electronic Tubes, Sidcup-by-pass, Sidcup, Kent, UK), dealt with the CRTs used in the system.

Millward stated that there are two distinct types of telecine in general use, photoconductive and flying spot. The former utilizes vidicon or lead oxide type camera tubes, the latter a CRT that produces a flying spot for scanning, to convert the information on the film to electrical signals. According to Millward, the flying spot system is superior to the phosphor system because of the availability of better phosphors and the fact that sprocketless-drive film transport can be used. He discussed various systems aspects, such as focusing coils mounted on gimbals, a photosensing system used for the correction of phosphor burn, and the fact that reproduction of interlacing requires a moving raster on the cathode ray tube with the concurrent requirement that geometry and brightness of the raster remain constant to an accuracy of 0.1% for geometry and 1% for brightness, so that registration errors will not occur.

R.G. Johnson, in discussing the flying spot scanning tubes manufactured by his company, stated a resolution of 0.002 in. to be typical. For good resolution, the phosphor decay time must be short (less than 0.2 μsec); for yttrium aluminum garnet (YAG) phosphors it is typically 0.1 μsec to the 10% level. Color scanning applications require a phosphor with a broad spectrum characteristic.

Early attempts to produce the optimum spectral image distribution relied on mixing two or more phosphors. While an acceptable characteristic could be obtained at the start of life, differential aging of the constituents caused changes in the spectral energy distribution after some time. Modern phosphors use rugged single-crystal materials such as YAG, which overcomes the disadvantages of the phosphor mixes and, in addition, after an initial burn-in carried out during manufacturing, exhibits a relatively flat light output response over the useful life of the tube. Johnson also discussed such other characteristics as luminous resolution, blemishes and flare. For example, Rank tubes are rejected if they have more than 10 "blemishes." To overcome flare, thick, tinted face plates are used to absorb multiple reflections.

I.S. Taylor (Linotype-Paul Ltd., Cheltenham, UK) followed this talk by reviewing the history of interactive displays, then described a visual display terminal for the printing industry that can display a tabloid newspaper at full size, with capability of interactive text manipulation.

A completely different subject, "Modern penetration phosphor multimode screens for cathode ray tubes" was discussed by J.R. Forman, representing Thompson CSF of Boulogne-Billancourt, France. The near-spherical phosphor grains in such CRTs actually consist of two or more different phosphors that are separated concentrically by dielectric material that is unaffected by electron bombardment. Color or persistence is changed by changing the voltage with which the electron beams strike the phosphor.

Forman stated that the advantages of such penetration CRTs over the standard three-gun color tube are that since only one gun is required, such tubes should perform extremely well in high vibration environments, have a stable spot position, and display pure color. Since the mechanical structure is simpler, the deflection angle is not limited by a color separation mask. Moreover, the sensitivity to stray magnetic fields is said to be less. Present tubes, with an intrinsic value of 12 line pairs/mm, have resolutions of 3 to 10 line pairs/mm at 50% modulation under normal lighting conditions, a performance said to be much better than that of the three-gun (shadow mask) tubes.

According to Forman, a penetration CRT with type E17 avionic phosphor can operate comfortably at 50 Hz refresh rate to give a light output of 480 cd/sqm, for a writing speed of 0.25 mm/μsec in the red and 1,100 cd/sqm for 1.0 mm/μsec in the green mode.

Because of the possible advantages listed earlier, such tubes have been considered as displays for aircraft cockpits. However, according to D.W. Hussey (Marconi Avionics Ltd., Rochester, Kent, UK), the first commercial airliner that is to use CRTs as primary cockpit instrumentation, the Boeing 767, is to use a shadow mask color tube. Hussey discussed the use of three types of tubes for aircraft cockpit applications: the penetration phosphor tube, the ordinary three-gun shadow mask color tube, and a CRT called the beam index tube (BIT). Unfortunately, even though this was a session on cathode ray tubes, he did not elaborate on the structure of the BIT. A little research since then has shown that a BIT has only one electron gun, has alternative rows of the three primary colors, and has an auxilary phosphor that emits ultraviolet (uv) radiation when struck by an electron beam and is so placed as to allow precise location of the beam. Matsushita is said to have developed such a BIT, though the only commercial use that seems to have been made of it to date is in a small, low-power, portable TV set that has not yet reached the market. Because only one gun is used, the advantage of the BIT is in its low power consumption. According to Hussey, a BIT would be an ideal tube for aircraft cockpit applications.

Hussey compared the three types of tubes, with the following conclusions:

	Penetration Phosphor	Shadow Mask	Beam Index
Hybrid Scan	Yes	Yes	No
All Raster Scan	No	Yes	Yes

Here the word raster refers to the usual type of scan found in a commercial television set. The hybrid aspect means that symbology is being generated cursively during the normal vertical retrace period. The all-raster scanning technique implies that symbol overlays are generated by modulating a video signal prior to its being mixed, for example, with scan-converted radar data.

Hussey stated that we can look toward more cathode ray tube data displays within commercial airliner cockpits, but that for a while the displays will look very much like the ordinary electro-mechanical displays, since this is what pilots are used to seeing. One change that will happen very soon, however, is that the displays on cockpit CRTs will be in color.

After Hussey's talk, a gentleman in the audience volunteered the information that, according to a study at the Karlsruhe Air Center (as listed in a EUROCONTROL report) when an air controller is fresh, i.e., at the beginning of work, the use of color adds nothing. But when the controller is fatigued as, say, after an hour, color does help.

The colloquium can be summarized by stating that the audience was exposed to some interesting current practices in the cathode ray tube field, that cathode ray tubes remain the electronic displays having the highest resolution, and that it certainly has become evident that cathode ray tubes have joined computers to accomplish fascinating new industrial tasks. (Irving Kaufman)

ENGINEERING

GRAZ: THE TECHNICAL UNIVERSITY—VISITS TO COMMUNICATION AND BIOMEDICAL ENGINEERING

Austria currently has three technical universities, or schools of engineering, in Vienna, Graz, and Leoben, plus a technical faculty at a new university in Linz. This report deals with the Technical University of Graz (TUG) and two of its institutes.

Graz, the second largest city in Austria (population 250,000), is located in the southeast corner of the country, about 30 miles from Yugoslavia and 50 miles from Hungary. Although it was heavily bombed during WWII, the destruction was restricted principally to the industrial and residential areas away from the center of the city. The center of the city was apparently virtually unscathed and therefore remains a beautiful example of the baroque Austria of the last several centuries. In 1978, Graz celebrated the 850th anniversary of its founding.

The city has both a university and technical university. This re-

port is the result of a visit only to the technical university, whose official title is Technische Universität Graz, Erzherzog-Johann-Universität.

According to the information provided by my hosts at TUG, schools of engineering arose in Europe in the early part of the 18th Century. For example, the Engineering School of Brussels was founded in 1716, that of Vienna in 1717. They were military in character and served chiefly to educate officers for the engineering corps of the armies. The schools of mining also date to the 18th Century, as, for example, the one in Freiburg in Saxony, which became a Technische Hochschule (engineering school) in 1765. Although, in addition, a number of universities at the time started lectures concerned with technology, mechanics, and related subjects, these either became oriented toward the pure sciences only or toward a legal education for those individuals interested in the legal aspects of construction and building. Somehow, in Europe the decision was made that universities should not be "polluted" with the education of engineers, so that until rather recently technical education has remained separate from the universities. Even now there is a non-uniformity in the degrees awarded. For example, according to one of the individuals from TUG, the University of Graz awards its first degree after 4 years of study, and that degree is the doctorate. TUG, on the other hand, has a 5-year undergraduate program which, I was told, actually stretches to an average time of 7 years. To get a doctorate from TUG requires an average total time of 10 years. This has created a dilemma, for when a graduate applies for a position after graduation, he is frequently asked "what degree do you have?" If the chief qualification is to have a doctor's degree, clearly the individual from TUG is at a disadvantage.

The origin of TUG is in the Joanneum, founded in 1811 in Graz by Archduke Johann. Although the Joanneum was originally a place for collection of specimens of natural science, it also started instruction, so that in the year 1861 as many as 21 subjects were being taught. In 1938 there were 400 students. Now there are about 5500 working toward the diploma (the first degree). There are 95 professorial chairs, with the professors assisted by 545 co-workers, who may be permanent staff or assistants working toward the doctor's degree. I found it of interest that students are referred to as "Hörer," not "Studenten" ("listeners," not "students"). This apparently originated from the custom that in most institutions of higher learning students come to the lectures only to listen and generally do not ask questions.

At present there are five faculties: Architecture, Civil Engineering and Construction, Mechanical Engineering, Electrical Engineering, and a Technical Faculty of Natural Science. TUG can boast of at least two famous alumni of the past: Walter Nernst and Nicola Tesla.

The Chief Executive Officer of the University is known as "Rektor." The head of a faculty is called a "Dekan." Both are elected and serve for limited periods of time. One of my hosts, o. Univ.-Prof. Dipl.-Ing. Dr. tech. Dr. Phil. Willibald Riedler (his complete title), Head of the Institute for Communication and Wave Propagation, was Rektor in 1975-77. The present Rektor (1979-81) is Prof. Werner Hollomey, Head of the Institute for High Rise Construction and Design. Another one of my hosts, Prof. Stefan Schuy (whose title is the same as Riedler's), Head of the Institute for Biomedical Engineering, is Dekan for Electrical Engineering for 1979-81.

The following are examples of some of the institutes in the various faculties. (In the majority of cases, each professor has his own institute.) In the School of Architecture we find an Institute for City and Land Development, another one for Art History, and another one for Construction Engineering. In Civil Engineering and Construction, among others, there is an Institute for Hydromechanics, Hydraulics and Hydrology. Examples in Mechanical Engineering are the Institute for Internal Combustion Engines and Thermodynamics and an Institute for Thermal Turbine Machinery. An unusual institute in this faculty is the Institute for Paper, Cellular Fabrics and Fiber Fabric Technology, which was founded especially to train people for the paper industry of the Steiermark (Styria), the province of Austria in which Graz is located. Examples in the Faculty of Technical Natural Science are the Institute

for Experimental Physics, the Institute for Theoretical Physics and Reactor Physics, the Institute for Microbiology, Water and Sewage Disposal Technology, and the Institute for Biochemical Technology and Food Chemistry.

Turning now to the Faculty of Electrical Engineering, we find nine institutes: (1) Electromagnetic Energy Transfer, (2) Power Systems, (3) High Voltage Engineering, (4) General Electrotechnology and Measurement Techniques, (5) Controls, (6) Electrotechnology (principally electronics in ice and snow), (7) Communications and Wave Propagation, (8) Biomedical Engineering, and (9) Bases of Electrical Engineering and Theoretical Electrical Engineering.

Prof. Riedler told me that there are about 1400 students in Electrical Engineering. I had wondered why students generally stay seven years, when the time required for getting a degree is only five. The chief reasons, I found out, are examinations, which do not have to be taken at the end of each semester but are frequently postponed, and the fact that a student has to complete a "Diplom" project before graduating.

In Electrical Engineering the first three years cover such subjects as mathematics, physics, mechanics, chemistry, basic electrical engineering and controls. The last two years cover basic power systems, basic electrical machinery, measurement technology, theoretical electrical engineering, practical electrical engineering, communications, plus a choice of a major in one of the five areas of (1) electric power systems, (2) machines, (3) electronics and communications, (4) biomedical engineering, (5) basic research.

Riedler, who has been at Graz for about ten years, has worked in ionospheric propagation, physics of the ionosphere, studies of the atmospheres of planets, telecommunications, and a VLF timekeeping station. His Institute has also participated in the orbital test satellite project of the European Space Agency, working with frequencies above 10 GHz. His group has looked at the influence of precipitation on microwave propagation, first in terrestrial links, then with satellite links. The Institute maintains a very extensive network of ground-to-ground stations for monitoring meteorological data around Graz and for measuring pollution (even Graz has a smog problem); it has been observing the hydrology of the area (for flood control), and is presently looking at sky noise with 12-GHz radiometers, under contract with the International Telecommunications Satellite Consortium, IntelSat. It has also been cooperating with the Russians on Venus probes, as well as participating in the NASA Space Lab Program.

Schuy directs the work of two other professors, five "Universitäts Assistenten" (equivalent in the US perhaps, to graduate students on up to senior researchers). He also has about 20 half-time assistants (of whom most are students), five lecturers teaching courses in his area, and half a dozen non-professional personnel.

Some of the courses taught in his Institute are Fundamentals of Biomedical Engineering, Medical Electronics, Biological Control, X-ray Technology, Theory of Electrical Networks, Data Processing of Electro-Physiological Parameters, Informational Physiology, Digital Simulation of Systems, General Physiology for Engineers, Anatomy, Biophysics, Biochemistry, Microprocessors and a course in Microprocessor Practice. Some of the recent undergraduate projects have dealt with the construction of specialized electronic boxes; the others have dealt directly with medical problems. For example, in a recent project on functional stimulation for scoliosis a student developed an electrical stimulator which puts out current in the range from 1 to 30 mA in a specially programmed manner and is used for stimulating the muscular system. It has been shown that such a direct functional stimulation arrests progress of scoliosis in 80% of the patients.

A project that I saw demonstrated was the measurement of ultrasonic power in the mW range by determination of the acoustic radiation pressure. Here 2-MHz acoustic energy is absorbed in a disc which has been connected to a microbalance. A measurement of the wave velocity and the force exerted on the balance, i.e., the rate of change of momentum of the acoustic energy, yields the energy density.

One of the two doctorate dissertations completed in 1978 deals with the fundamentals of the solid angle scanner—a method of improved ultrasonic medical diagnosis. The other one

deals with analysis of time-variant stochastic electrophysiological parameters. Among the research projects in progress, there is an investigation of the influence of extracranial applied electrical currents on the bioelectrical heart and brain activity. Another one, carried out at the request of the Austrian railway system, involves biosignal registration and processing for locomotive engineers during the process of driving the train. Then there is the interesting study supported by the Foundation for the Advancement of Scientific Research called the Influence of Electric Fields on Organisms. Schuy mentioned that in Russia people are permitted to work under a high voltage system for only a limited length of time, while in the US there is no such restriction. It would be of interest to determine if there is evidence that electric fields do indeed influence animal tissue.

A project which originated in the Institute and is now undergoing clinical testing is a technique of lithotrity in the ureter. In another one, an attempt is being made to continue treatment of malignant brain tumors after the original tumor has been removed. The objective is to destroy malignant cells in the immediate vicinity of the previous tumor by loading the cavity in which the tumor was with metallic powder, then heating this powder externally by high frequency electromagnetic waves. At the time of my visit it had been demonstrated with a 62-year old patient who had had metallic powder inserted in a cavity in the brain in this manner that the local temperature did indeed rise. How successful this technique will be ultimately is yet to be determined by clinical tests.

Schuy and his group presented 27 papers at technical meetings and published 18 journal articles in 1978. If Riedler's and Schuy's Institutes are examples of what is being done everywhere at the Technical University in Graz, there is no doubt that this University is a most successful contributor to its country and to technological progress in the world. (Irving Kaufman)

PRACTICAL EXPERIENCES WITH FLOW-INDUCED VIBRATIONS

The symposium on Practical Experiences with Flow-Induced Vibration, sponsored jointly by the International Association for Hydraulic Research (IAHR) and the International Union for Theoretical Applied Mechanics (IUTAM), was held at the University of Karlsruhe, (West Germany), 3-6 September 1979.

Symposium co-chairmen, Prof. E. Naudascher (Univ. of Karlsruhe) and Prof. D. Rockwell (Lehigh Univ., PA), stressed the interaction between the researcher and the practicing engineer; and in fact, of the 200 attendees from 25 different countries, 142 were associated with industrial and government rather than university laboratories. These attendees represented engineering and scientific interests in flow-induced vibration in 6 different areas of application: reactor and heat exchanger components; ocean structures; hydraulic machinery and equipment; bridge decks, beams, and cables; high-rise buildings and structures; and hydraulic structures and ship structures. Each of these topics was covered by a separate (nonconcurrent) session consisting of a general state-of-the-art lecture, several invited papers, and a number of contributed papers. Because the participants were provided with 3 volumes of preprints 6 weeks prior to the Symposium, the major emphasis was on discussion and technical interchange rather than the presentation of these contributions. This format, together with an evening workshop on prediction and modeling, an evening film session illustrating practical experiences, and a panel discussion on unresolved problems, provided a focus on many aspects of flow-induced vibrations.

In this attendee's view, this arrangement provided a very effective format. The collection of experts representing so many different areas of application, but at the same time trying to understand the same physical phenomena, was stimulating. As a result, one was exposed to many different interpretations of the same phenomena. It was also a very busy format that did not conform with the original intent of Karlsruhe, which loosely translated means "Charlie's Rest." Attendees did not have the opportunity to rest.

In the following sections each of the topical sessions will be sum-

marized, and the unresolved problems identified in the closing session will be highlighted.

Reactor and Heat Exchanger Components. The state-of-the-art lecture in this area was presented by Prof. M. Paidonssis (McGill University, Canada), and represents a good summary that would serve as an excellent introduction to practicing engineers in related areas. According to Paidonssis, the US Nuclear Regulatory Commission reported 261 shutdowns or power reductions between May 1974 and December 1975 for other than refueling or maintenance purposes. Flow-induced vibrations caused 23 of these shutdowns, indicating a real, though not overwhelming, problem. The majority of problems can be attributed to fluid-elastic instabilities, and the physical phenomena in this area are not completely understood. A similar lack exists in the complex flow occurring in cross-flow heat exchangers. Unfortunately, there are not enough precise data to permit the design of new heat exchangers that would avoid flow-induced vibration problems. The nuclear industry has been fortunate in that detection of such a problem is possible before a catastrophic accident results and the problem can usually be corrected by the addition of structural support. However, this process is very costly in terms of lost operating time. The conclusion is that data permitting the design of heat exchangers and boilers to avoid flow-induced vibration are lacking.

Ocean Structures. The papers on ocean structures were concerned with drilling platforms, pilings, etc., and their interactions with ocean waves and currents. Dr. L.R. Wootton (Atkins R&D, UK) pointed out that there have been few failures experienced with these structures, even in North Sea installations. Although Wootton seemed to indicate that there were no problems in this area, several participants seemed to disagree. This author concluded that these problems were being avoided by "over" design, which is economically undesirable. There is therefore a need for more research, but not on an urgent basis.

Several problems related to the handling of these structures and transportation to their installation site were mentioned. Again, economics control the construction of special handling devices and the time required to transport. This author is aware of scale-model tests conducted at the Netherlands Ship Model Basin (Wageningen, the Netherlands) to assess the problems of transportation, unloading, and mooring of these structures. Although significant scaling problems exist between the model and the prototype, a sufficient data base of experience will usually prevent major adverse consequences.

Hydraulic Machinery and Equipment. This topic area was the only one without a general lecture. Instead, two invited papers were presented, together with an excellent review by Dr. B. Chaix (Federal Institute of Technology, Zurich, Switzerland) during the closing session. Because hydroelectric power generation is an old technology (compared with others discussed at this meeting), there is a good base of available experience. However, while most problems which arose have been solved, there is a need for development of design methods which will prevent the occurrence of problems known to have occurred in previous designs. This conclusion seems to be an indication of the need for more basic research in hydraulic power-generating equipment.

Problems experienced in flow-induced vibrations of hydraulic machinery are by no means limited to the turbine alone. Significant problems include vibration of the inlet trash rack (which prevents the ingestion of foreign material into the turbine), cavitation and flow separation in the penstock (leading to the turbine), and cavitation in the draft tube (exit of the turbine). The latter problem was vividly demonstrated by a film presented by T. Kubota (Fuji Electric Co., Ltd., Japan) showing the cavitating vortex which creates draft-tube surge. The viewer was readily convinced that this form of cavitation can induce vibration.

Bridge Decks, Beams, and Cables. The classic example of flow-induced vibration in bridge structures is the collapse of the Tacoma Narrows bridge in 1949. The deservedly famous film footage showing the collapse of this bridge vividly demonstrates the necessity to study fluid mechanics. Prof. R.H. Scalan (Princeton University, USA) presented the general lecture on this topic, and pointed out that while much effort has been made to explain the collapse of the Tacoma Narrows bridge,

additional insight is still required in the study of bridge stability. This is particularly true when considering the consequences of the motion of the structure, i.e., aeroelastic effects.

A major difficulty in this area is the structural complexity of a bridge, making it difficult to represent as a mathematical model. As result, there must be a strong reliance on experimental evaluation. This approach presents a problem in producing aeroelastic scaled models for evaluation in a wind tunnel because the models are so small. Also, the definition of the flow field in which the structure must operate is difficult, particularly with regard to the turbulence characteristics of the flow.

Significant progress has been made in the analysis and evaluation of bridge structures since the Tacoma Narrows failure, but there is need for additional effort.

High-Rise Buildings and Structures. These structures experience many of the same problems as those just discussed. In the general lecture, Prof. A.G. Davenport (University of Western Ontario, Canada) emphasized the importance of turbulence on the forces generated on high-rise structures. The employment of scale-models in a wind tunnel has been successful in providing great insight for the design of these tructures. The World Trade Center in New York, one of the first structures to be designed using wind-tunnel data, was equipped as a result with a system to damp the vibration of the structure.

Even with this, and other examples of the success of wind-tunnel modeling, vibration can eventually lead to structural damage. Further research to establish realistic design constraints is required. This effort should be coupled with an up-grading of existing building codes, which at present usually do not reflect the existence of flow-induced vibrations.

Hydraulic Structures. In his general lecture Dr. P.A. Kolkman (Delft Hydraulic Laboratory, the Netherlands) discussed a number of experiences with vibration of the gates employed in locks and sluices. The details of papers presented in this session are difficult to summarize because of the complex flow involving an air-water interface and cavitation. Workers in this area should study the details of the excellent papers here.

Ship Structures. This was one of the smaller sessions, partly because this subject is of major interest to other organizations such as the International Towing Tank Conference (ITTC), and is covered by other symposia. In the general lecture, Dr. J. Breslin (Stevens Institute of Technology, Hoboken, NJ) pointed out that research in flow-induced vibration has long been recognized as an important topic, and dates from the late 1800s. Much of the pioneering research was conducted by Lewis at Webb Institute of Naval Architecture, NY, in the 1930s, where he developed methods for measurement of time-dependent propeller forces. Subsequently, complex three-dimensional prediction techniques have been developed to predict these forces accurately.

It appears that many of the research results in this area could be applied to similar problems in other areas, such as hydraulic machinery. Until this meeting many of the attendees were uninformed of the efforts in the area of ships vibration. The Symposium truly fulfilled one of its purposes by bringing people in these two areas together and providing an interchange of knowledge.

Although the importance of ship vibration is obvious in military applications, the emphasis in commercial shipping is toward providing comfort and avoiding hull failure. This emphasis was demonstrated by a paper describing the problem of a "singing" propeller on a boat which was intended to provide sleeping accommodations for New York harbor pilots. The resulting hull vibration would not allow the pilots to sleep. A correction to this propeller-originated problem was obtained by modifying the shape of the trailing edge of the propeller to alter its vortex shedding characteristics. This modification mismatched the shedding and hull resonance frequencies and eliminated the problem.

The proceedings of this Symposium should be studied by persons involved in either research or engineering applications concerned with flow-induced vibrations. They can be obtained from the sponsoring agencies (IAHR or IUTAM) or the Institute for Hydromechanics, University of Karlsruhe. (R.E. Henderson, The Pennsylvania State University)

FLUID MECHANICS

THE DEPARTMENT OF MECHANICS AT THE UNIVERSITY OF OSLO

The Department of Mechanics at the Univ. of Oslo is a part of the Institute of Mathematics. The director of the Department, Prof. Bjorn Gjevik, has recently taken over from the senior professor of the Department, Prof. Enoch Palm. The Department graduates 90 students per year, and has a total of 20 graduate students; the undergraduate students take a program in mathematics, physics, geophysics, and mechanics over a time span of 3 1/2 years for their first degree. In addition to Palm and Gjevik there are 4 additional faculty who are engaged in teaching and research.

Though no engineering is taught at the University, the research program in the Department of Mechanics resembles that of either a Department of Engineering Mechanics or Engineering Science in an engineering school in the US. It is mostly in the area of fluid mechanics. In this connection Palm and Dr. Mårten Tveitereid are studying the nonlinear stability of low-Prandtl-number, thermally driven convective flows (at a small overcritical Rayleigh number) in a horizontal fluid layer. The resulting convective flow tends to form two-dimensional rolls that oscillate. These oscillations are being studied for a fluid with constant viscosity. Also with Tveitereid, Palm is studying the properties of two coupled, generalized Van der Pol equations for various initial conditions. Depending on the coefficients of the equations and the initial conditions, the solution may approach a limiting closed trajectory in phase space or demonstrate divergent behavior.

Another problem being considered by Palm and Tveitereid is the nonlinear oscillations of a heaving ship. The usual approach is to study the response of the ship to the waves. However, in this analysis they are considering a forced ship motion which results in a wave pattern about the ship. In still another problem, thermally driven convection in an annular, circular Hele-Shaw cell is being investigated from both experimental and theoretical points of view. In this research such a circular cell whose plane is vertical is driven by heating at the inside surface and by cooling at the outside surface in the presence of a gravitational field. Twin convection patterns in the cell are formed which carry the heated fluids upwards along the inside of the annulus until the flow contacts the cooled outer surface, whereupon the currents flow downward and around the outside to a lower stagnation point and upward again towards the heated inside.

Gjevik is studying air flow about the island of Jan Mayen off the coast of Iceland. This island is 70 km long with peaks over 2000 meters high. When the wind blows over the island, the wake pattern displays interesting hydrodynamic properties, and so Jan Mayen has become the object of study of many geophysical fluid dynamicists. In such flows two different situations can arise, one in which the flow past the island is slower than the velocity of propagation of a gravity wave in the atmosphere and the other where it is faster. In the case of the higher flow velocity, the wake in the flow behind the island resembles that of a von Karman vortex trail. Such a vortex trail represents a large-scale coherent structure in the turbulent wake whose Reynolds number may be of the order of 10^8. The properties of such a coherent structure can be described by considering the wake flow as marginally unstable. In the case of the lower flow velocity, the wake contains a wave pattern of lee-waves similar to those of a ship plowing through the ocean. It is the property of these lee-waves that Gjevik is now studying intensively with T. Mårtensen, a graduate assistant in the Department.

In connection with E. Mårtensen (another assistant in the Department) Gjevik is numerically modeling long barotropic waves in storm surges along the western coast of Norway using direct integration of the hydrodynamic equations. Gjevik is also studying ramp waves on a beach in connection with the problem of how far impinging waves run up on a beach.

Dr. Arnold Bertilson is investigating hemodynamic flows in bends and bifurcations, assuming that the fluid is Newtonian. The study in bends involves oscillatory flows, whereas in the bifurcating cases the flows are steady. In both cases the secondary flow in the cross-sectional plane of the tube is measured and compared with theoretical results. In another important study, two-fluid turbulent

flow in pipes and piping systems is being investigated to determine where such flows separate. In pipeline transport of crude oil a considerable amount of water is mixed with the crude; when such flow passes through bends and bifurcations, the water separates out and corrosion problems result at such points of separation. Hence it is important in new piping systems to predict where such troubles will occur before the fact.

From all that I could observe, this Institute is continuing with its tradition of quality research. (Martin Lessen)

THE INSTITUTE FOR THERMODYNAMICS AND FLUID DYNAMICS AT THE CHALMERS TEKNISKA HOGSKOLA

The Institute for Thermodynamics and Fluid Dynamics at the Chalmers Technical University is headed by Prof. N. Frössling who is in his final year before retiring next June. Frössling has as his staff Dr. Bo Attelqvist, who is a Universitets Lektor (with a corresponding American rank of Associate Professor), and Dr. Gunnar Johansson who is a Forsker (research) assistant with the rank of Assistant Professor. There are 10 assistants in the Institute, all of whom are graduate students, having the MS degree and working toward the doctorate. The School of Mechanical Engineering graduates 175 students each year with the title "Civil Ingenjür." This degree is the equivalent of our MS degree. Ninety percent of entering students graduate.

The Institute teaches two required courses for all undergraduates, one being in general equilibrium thermodynamics and covering the laws of thermodynamics along with the analyses of open and closed cycles, and simple processes. The second course is an introduction to fluid mechanics that deals with the basic equations of fluid mechanics such as the extended Bernoulli equation and the Navier-Stokes equations, and treats pipe flow, two-dimensional wing theory, hydrodynamic similarity, basic heat transfer, energy considerations, and one-dimensional compressible flow. In addition there are two optional courses for undergraduates that cover potential theory, compressible flow, boundary layer flow, and heat transfer in depth. The graduate course offerings at the Institute are in mathematical and experimental techniques and methods, advanced fluid mechanics, heat and mass transfer, and reversible and irreversible thermodynamics. In addition to the preceding required graduate courses, there are elective courses in aerodynamics, boundary layer theory, turbulence, turbulent boundary layers, turbulent transport, research techniques, non-Newtonian flows, turbulence closure methods, and the like. There are also reading courses in magnetohydrodynamics, kinetic theory, the fluid mechanics of turbomachinery, energets, and ship hydrodynamics.

The research program of the Institute is involved in studies of boundary layers, turbulence, and turbulent heat transfer. In the area of heat transfer Johansson is constructing a laser Doppler velocimeter to obtain three-component multipoint data at as many as five points simultaneously. In the area of boundary-layer research a student, Lennart Löfdahl, is measuring the Reynolds stresses at the stern of a ship model (he has already studied the Reynolds stresses at the front of the same model). This model consists of the subsurface portion of a cargo ship with the hull doubled so that the model is symmetrical. This eliminates surface wave effects when the model is tested in the wind tunnel. The model is 2 m long and there are no propellers at the stern; the boundary layers near the stern probably separate ahead of the point where they normally would in the presence of thrusting propellers. The Reynolds stress is obtained by a rotating hot-wire probe. All values of the Reynolds stress are available once the principal values and the principal orientations of the Reynolds stress are known. In this regard the traverse gear developed at Chalmers has a directional accuracy of 0.2° and a linear location accuracy of 10 μm. The experimental techniques have been fully tested on a flat plate 3 m long at a free-stream velocity of 60 m/sec. The tunnel used has a test-section cross section of 1.8 m × 1.25 m and a turbulence level of 0.1% of the free-stream velocity.

Another student, Rolf Karlsson, is studying skin friction of rough surfaces. Replicas of ship hull surfaces with different degrees of fouling (from a freshly painted surface to one which was at sea for two years) are

tested in a wind tunnel. The surface samples are 1 1/2 m long × 70 cm wide, and each contains a "floating" element on which drag forces are measured. Such a study can yield only comparative data because the fully developed boundary layer ahead of this replicated sample cannot be reproduced in the wind tunnel.

A water channel 35 cm × 60 cm × 6 cm long is being readied for boundary-layer studies. The channel is slowly divergent on the top to compensate for buildup of boundary layer displacement thickness. The channel can operate at water speeds of 0.05 m/sec to 0.3 m/sec with a maximum Reynolds number of 1.5×10^6 based on channel length.

Studies in heat transfer during flow over a wedge are being readied in which a wedge 1/2 m long with a base 8 cm wide will be studied in a wind tunnel. The solid steel wedge which is heated at its base has a wire to trip the boundary layer into turbulent flow at its apex. The temperature distribution along the flanks of the wedge will be measured in free-stream flows up to 40 m/sec. The purpose of the experiment is to compare observed data with the closure model of Spaulding and Patankar. The temperature field about the wedge will be obtained through infrared TV scanning photography, with the camera data being reduced in real time.

In another experiment, this group is studying heat transfer from a circular cylinder of diameter 30 cm as influenced by the ratio of the macroscale (typical eddysize) of the free-stream turbulence to the diameter of the cylinder. It is intended to compare experimental data obtained from the flow field with calculations made by using a turbulence closure scheme according to Saffman. The research is being performed by a student, Bengt Sunden.

In view of the small size of the Institute the research program in fluid mechanics and heat transfer is active and impressive. It is hoped that a worthy successor for Frössling will be found. (Martin Lessen)

MATERIALS SCIENCE

PHYSICAL CHEMISTRY APPLIED TO PROBLEMS OF METALS

At the Politecnico di Milan, I recently had the opportunity to visit an unusual research group called The Institute of Physical Chemistry, Electrochemistry, and Metallurgy. The marriage of these three disciplines is rare in the US, and I found that materials problems are often approached in unconventional fashion at this Institute. The dominant theme of the diverse activities is surface interactions, and the joint studies by chemists and metallurgists include — corrosion, chemical treatment, and catalysis.

My host, Dr. Pietro Cavalloti, was trained as an electrochemist, with early interests in electrocrystallization and reactions in fused salts. He gradually began to apply his background to metallurgical problems, so that now the general theme of his assorted interests can be said to be the application of physical chemistry principles to the solution of problems of metals. His output is fantastic, particularly in view of the limitations of the educational system in which he operates. Cavalloti is one of the many nontenured members of the university staff, in spite of his ten years at the Polytechnic. He plays the role of an Associate Professor who both teaches and does research, but at the time of my visit his appointment was in jeopardy by the terms of the latest educational bill being proposed by the government. In spite of this gross lack of incentive, Cavalloti, as do many others in the same position, carries on research activities that would be the envy of any top-notch university. His current interests include chemical treatment of surfaces, corrosion of gas turbine superalloys, reduction of ores, catalysts in fuel cells, and modeling of complex chemical reactions at surfaces. Surprisingly, the laboratory facilities that I was shown were outstanding, reflecting an anomalous imbalance between university funds for equipment and for salaries.

The activities covering chemical treatment of surfaces currently center on ceramic hard magnetic materials, particularly barium or strontium hexaferrite ceramics, in which the mechanical integrity of products obtained by powder metallurgy methods is often a critical problem. To obtain good contact between the magnetic hard phase and the binder phase, the best method is to coat the powder with a metal binder, the preferred metals being cobalt and nickel; this also yields a product with good strength at relatively high temperatures. Cavalloti's group has been considering the relative merits of the several methods which may be used to create the metal layer on the powder. The main possibilities are chemical plating of cobalt and nickel from aqueous solutions, with reducing agents such as sodium hypophosphite or hydrazine, and electroplating. Development of the chemical plating method has been emphasized in work at Milan, mainly because of its applicability to nonconducting substrates. Experimental characterization of the process and the resulting composite materials are accomplished by a variety of techniques, including magnetometry, demagnetization curves, x-ray diffraction, compression tests, and fractography. The work also includes theoretical considerations of the coupling between the two magnetic phases in the composite hexaferrite materials, by consideration of microstructural, crystallographic, and magnetic properties.

In related work on a more fundamental level than that of the hexaferrite studies, Cavalloti and co-workers have examined the crystal growth aspects of chemically reduced cobalt on face-centered-cubic (copper and nickel) single-crystal surfaces. One of the interesting aspects of this is the occurrence of martensitic transformations and growth twinning in the thin cobalt layers. This work does have potentially high practical value, since cobalt and cobalt-alloy films formed in this way are employed as magnetic materials, yet their properties are quite structure-sensitive.

"Hot corrosion" of nickel-base superalloys for gas turbines is being studied by means of some original thermogravimetric and electrochemical methods, and also by scanning electron microscopy and x-ray emission images of cross sections of corroded samples. The long-standing diffuculty in understanding hot corrosion can be attributed to the complexity of both the environment and the material. Both are comprised of many components and many phases. Since this type of corrosion is important from a practical standpoint, empirical tests are often utilized to assess the corrosion resistance of different alloys, but these contribute little to clarifying the operative mechanisms of corrosive attack. Cavalloti's work has sought to separate some of the effects, including the effect of metallurgical microstructure and heat treatment, the influence of chromium content of the alloys, and the role of volatile compound formation on the surface.

Usually, basic studies that pursue mechanisms tend to have low predictive value relative to the performance of real alloys in service, but the work at Milan is striving hard to close this gap. They are particularly interested in delineating the mechanism of hot corrosion during the catastrophic stage. A special thermogravimetric technique, whereby volatile compounds formed in this stage are gettered by a bed of alumina pellets, is used to measure total oxygen pickup by a sample. The equipment for thermogravimetry is impressive. Cavalloti feels that greater attention should be paid to electrochemical methods for evaluating the resistance of alloys to hot corrosion, since in the catastrophic stage the reactions are essentially electrochemical. Therefore, the experimental work includes potentiodynamic techniques, widely applied in aqueous corrosion environments, used here in molten salts.

Cavalloti indicated that in future he wants to return to the common physical chemistry base of these diverse experimental endeavors. He is currently expanding his laboratory work to studies on catalysts in fuel cells, but is concentrating his thoughts on the development of new models for complex chemical reactions at surfaces. The general method used is essentially a quasichemical approximation to multiphase equilibria, with the idea being to calculate the equilibrium concentrations in the difficult case when several phases are present and several

chemical reactions are on-going. Published methods present difficulties when some species concentrations become very small during the course of computation and when species are simultaneously present in several phases. There are two major classes of methods: one reduces the problem to the algebraic solution of a set of simultaneous nonlinear equations; the other involves the search for the minimum of a function (generally the free energy of the system) by optimization techniques. The first type is more specific and, therefore, more directly related to the process simulation; the second one is more suitable for complex systems and can be easily generalized. Cavalloti and co-workers have tried to develop a general solution algorithm with advancement degrees as main interaction variables, thus minimizing the complications inherent to stoichiometric balances, and at the same time giving a general procedure for the initial choice of the independent component set and the first trial values of the interaction variables. The details of these calculations are too complex to describe further. Suffice it to say that the method has so far been applied with success to several practical processes, including the steam cracking of ethane, combustion of propane, and synthesis of urea.

Although I did not have the opportunity to discuss their research in detail, several other members of the Institute deserve mention. Notably, there is a separate group on aqueous corrosion, comprising Dr. Bruno Mazza (not to be confused with Prof. Franco Mazza at the neighboring Univ. of Milan) and Dr. Pietro Pedeferri, who are concentrating on problems of stress corrosion cracking in alloy and stainless steels.

At the time of my visit to Milan, the faculty of the Polytechnic was on strike in response to the continued failure of the legislature to pass an acceptable educational bill. As is well known, university faculty in Italy are faced with extraordinarily large classes (two hundred is not unusual) and very low salaries. This situation is, of course, quite relevant to the issue of research productivity at the universities. The two main factors seem to be a lack of time available to devote to research and a lack of inspiration owing to the overwork/low-remuneration situation. Cavalloti, for example, has been able to maintain impetus for his work only by collaborating closely with industrial firms and government laboratories, such as CNR (Consiglio Nazionale delle Richerche, Parma), Fiat (Turin), and LTM (Milan). The faculty members who do manage to maintain credible research activities are all the more praiseworthy when one considers these nonnurturing aspects of the university environment. (Jeff Perkins)

POLYMER AND SURFACE SCIENCE AT STRASBOURG AND STRATHCLYDE

It is difficult to imagine that the cities of Strasbourg in France and Glasgow in Scotland could have anything in common. The heavily industrial and thoroughly modern Glasgow bears little resemblence to the medieval Strasbourg with its canals and colorful Alsatian houses. Nonetheless, both are home for research groups with strong and very similar efforts in polymer and surface science. Moreover, both have benefited from strong leadership by distinguished polymer scientists. In Strasbourg there is the Centre de Recherches sur les Macromolécules (CRM) headed until recently by Prof. H. Benoit; and in Glasgow there is the Department of Pure and Applied Chemistry, Univ. of Strathclyde, headed by Prof. A.M. North.

Benoit, whose contributions to the structure-property relationships of polymers have been quite considerable, has left CRM for a chair at the Université Louis Pasteur. The present director of CRM is Prof. M. Wippler.

The CRM was founded in 1948 to consolidate government research on macromolecules. Initially, the work was divided into chemical synthesis, physical chemical characterization, and biopolymers. In 1959 they moved to their present location in the northeast corner of Strasbourg, and the biological research was split off to the Université de Paris and sites in Strasbourg including the Université Louis Pasteur. Also, chemical synthesis is no longer contained in a distinct group. Present emphasis is on the physical chemistry of polymers with the accent on physics. The staff consists of 60 professionals and 70 support people including a healthy

number of technicians. The bulk of the funding comes from the CNRS; most of it is for normal expenses, although there are occasional grants for special topics designated by CNRS. About 20% of the support is contract research from the Délégation Générale à la Recherche Scientifique et Technique (DGRST). Private industry contracts with CRM on a matching-fund basis. The CRM staff does some teaching at the Université Louis Pasteur.

Our host was Dr. G. Weill, who gave a detailed account of the entire research program. He began with the study of the solution properties of polymers, in which the work is divided into finding better methods of characterization, theory, and small-angle neutron scattering (SANS) experiments. Their theoretical work has led them to the conclusion that solution behavior is critically dependent on the size of the polymer molecule, but molecular dimensions are not only difficult to determine but usually there is a size distribution. However, the very powerful SANS technique for determining polymer size and size distribution could change this situation, and CRM is very active in using the instrument at the Institut Laue-Langevin, Grenoble, not only in their solution work but in their solid-state work as well.

In the area of gel-permeation chromatography (GPC), they are primarily interested in better calibration methods, and they feel that the essential parameter is the hydrodynamic volume; the product of the intrinsic viscosity and molecular weight. Also, they are working to correlate GPC with viscosity and light-scattering measurements.

The strong, high-modulus polyaramid fibers (such as duPont KEVLAR) are getting a lot of attention from polymer scientists all over the world. At CRM they are asking how much molecular rigidity is needed in the polymer backbone to get useful fiber moduli. They are also looking into the liquid crystal structure of the highly polar solutions from which the polyaramids are spun.

One of the larger efforts at CRM is with polyelectrolytes. Actually, it is a leftover from the biochemistry group, but now the emphasis is on their use in enhanced oil recovery and, in the solid state, as models of charged surfaces. In the work related to oil recovery, the emphasis is on the interaction of the polymers with metal cations, including cation specificity and the state of the water associated with the ions. They are using NMR to look at the water structure and the mobility and distribution of the cations. Ultrasonics is used to determine the kinetics of polyelectrolyte/cation as association. They are interested in the aggregation of the polyelectrolytes by multivalent cations and the dynamics of the aggregation of the polymers into micelles and microemulsions.

A group headed by Dr. A. Skoulios is concerned with the mesomorphic (liquid crystal) state of polymers in bulk and in solution. They are working on block copolymers, such as styrene/butadiene/styrene, where the hard segments can organize into lamellar, spherical, or cylindrical structures within a matrix of the soft segment. They have found that shear deformation can be very effective in developing lamellar or cylindrical morphologies. Although they are able to use liquid crystal surfactant solutions to model the behavior of block copolymers, they find that not all the structural defects found in typical liquid crystal soap systems are possible in liquid crystal polymers.

In the early 1960s Dr. A.J. Kovacs of CRM contributed considerably to our understanding of the glass transition (T_g) phenomena in polymers and other solids. His point of view is that the T_g is not a true second-order transition, but depends in a fundamental way on the thermal history of the material. He claims that the T_g occurs when the rate of molecular fluctuation equals the rate of cooling. Nonetheless, the phenomena associated with T_g provide useful information about the physical aging (molecular relaxation) of glasses. Very recently, he has developed a theoretical analysis [*J. Polym. Sci., Phys. Ed.*, 17, 1097 (1979)] in which he defines a retardation time that characterizes the thermal history of the glass in terms of its deviation from the equilibrium state it would attain if cooled infinitely slowly.

When a solid polymer is processed by a stretching or drawing operation, the reorientation of the chains importantly affects the mechanical properties. At CRM they are using SANS, along with fluorescence dichroism and NMR, to determine the effect of deformation

on orientation. Among the things they have found is a strong orientational anisotropy with respect to the draw direction, depending on the drawing conditions.

A relatively new area of interest at CRM is the adsorption behavior of polymers at solid/liquid interfaces. This work relates to the oil-recovery problem, since the adsorption of the polyelectrolyte can seriously restrict flow through the porous reservoir. It is also applicable to the stabilization of colloidal soils, and in living systems where flow through pores may be controlled by structural changes of adsorbed biopolymers. This work is largely in the hands of Dr. P. Dejardin and Dr. R. Varoqui, and their principal technique is to measure the effect of the adsorbed layer on flow rate through membranes of known pore configuration. They have shown that the solvent profoundly affects the layer thickness, and that the effect correlates with the Flory polymer-solvent interaction parameter.

In cooperation with Dr. S. Candau and others at the Laboratoire d'Acoustique Moléculaire, Université Louis Pasteur, the people at CRM, notably Dr. J. Herz, are studying polymer networks in the swollen state using inelastic light scattering and mechanical testing. This research is related to natural gels, contact lenses, and possibly the development of artificial eye components. The underlying scientific purpose is to test two fundamentally different models for inelastic light scattering by swollen polymers. The first model, the corpuscular theory, treats the gel as a collection of independent particles moving harmonically under Brownian motion about stationary positions. The second, the hydrodynamic theory, assumes the gel is a continuum and that scattering is from cooperative diffusion of the network chains. Candau and Herz come down strongly in favor of the hydrodynamic model. One interesting outcome of this work is that for gel networks where there are pendent chains, the hydrodynamic properties (from light scattering) and the elastic modulus do not correlate with the same network substructure. Both parameters are needed to characterize the network.

The success of the model gel research and, indeed, of most of the CRM work, depends heavily on the polymer synthesis capability by Herz, Dr. P. Rempp, and Dr. E. Franta. Rempp and Herz utilize anionic polymerization schemes to synthesize living polymers, and block and graft copolymers with narrow molecular-weight distributions. It is essential in making physical measurements on these polymers that the molecular-weight distribution be as narrow as possible. Franta is investigating cationic polymerization to form cationic living polymers. Another part of the CRM synthesis program is to try to incorporate phosphorus and sulfur into polymer molecules; phosphorus to impart low flammability and sulfur as a means of using sulfur stocks being generated from gas production in southern France.

The Univ. of Strathclyde claims to be the oldest technical university in the world. It began as Anderson's Univ. in 1796 (see John Anderson and the College He Founded, James Muir, 1950, Clark Ltd., Glasgow), later to be renamed the West of Scotland College of Science and Technology, then the Royal Institute of Science and Technology, and finally the Univ. of Strathclyde. It was founded by Anderson to serve the Industrial Revolution, and continues to retain its technical orientation. It is official school policy that 55% of the studies must be in some area of technology.

Prof. N.B. Graham was our host in the Department of Pure and Applied Chemistry. He claimed that the Department has the largest research budget of any university chemistry department in the UK: half a million pounds. Two thirds of this money comes from the SRC and one-third from industry. The Department is divided into the Chemical Technology Section, headed by Graham, and the Physical Chemistry Section, directed by North (who heads the Dept.). The undergraduate curriculum includes two years of chemical technology (applied chemistry, including chemical engineering), applied physical chemistry, and options chosen from polymer science, fuels science, applied surface chemistry, and advanced chemical engineering. At the graduate level, besides the normal research-based PhD and MSc programs, there are nonresearch MSc programs in Industrial Analytical Techniques and Applied Surface and Colloid Science.

At Imperial Chemical Industries, Graham developed an interest in hydro-

philic polymers, and much of his research since coming to Strathclyde is a continuation of this interest. Hydrophilic polymers such as polyethylene oxide have functional groups capable of interacting with water by hydrogen bonding or ionic hydration. One of their useful features is that they are usually biodegradable and so are more acceptable as detergents or water-treating agents than other polymers. Graham's specific interest is with hydrophilic polymers which swell in water at room temperature and then shrink but retain ionic solutes when the temperature is raised. These materials can be used for desalination or solution-concentrating purposes, and with less energy expenditure than evaporation/condensation processes.

Another use of hydrophilic polymers is for controlled drug release. Hydrogels (hydrophilic polymer networks) containing a medication are either implanted or injected into the patient, and as the gel is metabolically degraded the drug is slowly released. Graham is receiving support for work in this area from the World Health Organization (WHO). The WHO would like to use controlled drug release to combat tropical diseases. Graham has synthesized nontoxic gels and is investigating their physical structure. Some of the materials he has prepared are undergoing toxicity tests with laboratory animals.

Dr. D.B. Hough recently joined the staff at Strathclyde from the University of Bristol, where he worked with Prof. R.H. Ottewill. Since his arrival he has established and supervises the MSc course in Applied Colloid and Interface Science. In his research, Hough has undertaken a study that relates to the so-called "dry-eye" condition, where the normal fluids which keep the eye moist are absent or in low supply. The idea is to supplement the fluid in the eye with a solution of hydrophilic polymer (such as polyvinyl alcohol) and inorganic salts. In the right proportions, the polymer and salt ions would form a thin stable film over the eye surface. Hough is developing an *in vitro* model in which an air bubble is forced through a solution of polymer and salt onto the underside of a plate of a transparent hydrophobic solid like polymethylmethacrylate. By viewing through the plate he can observe the stability of the thin liquid film between the plate and the bubble.

The group at Strathclyde, like their counterparts at Strasbourg, are enthusiastic about the use of SANS to characterize polymers in concentrated solutions and in the solid state. Most active of the Strathclyde people in this field is Dr. R.W. Richards, who has used the instrument in Grenoble as well as the somewhat less-capable facility at the Atomic Energy Research Establishment, Harwell. Richards has examined polymer dimensions in very concentrated (80-90%) solution, chain size in block copolymers as a function of morphology, and the nature of the interface between regions of different morphology. Currently he is measuring chain dimensions in polyethylene oxide/polyurethane interpenetrating network polymers. He would like to use SANS to study the conformation of polymers adsorbed on silica spheres. He has written a very readable review on determining the molecular dimensions of polymers by neutron scattering (*Polymer Characterization*, Vol. I, J.V. Dawkins, Ed., App. Sci. Pub., Essex, 1978, p.117 ff).

Dr. I. Bengough is investigating the kinetics of fluidized-bed, thermal polymerization of styrene. From an extensive examination of the effect of inhibitors and initiators on the kinetics, he concludes that the mechanism of bulk polymerization differs from that in solution, a diradical intermediate being involved in bulk. Bengough is also studying the photocuring of polyesters. Using styrene-diethylfumerate as a model system, he finds that a radical intermediate is involved which for some reason is not inhibited by oxygen.

Dr. L.R. Cox has some rather unconventional ideas about the mechanism by which long-chain polymers delay the *onset of turbulent flow, i.e., drag* reduction. Most workers believe that single polymer chains inhibit eddy-current formation by flow-induced conformational changes. Cox contends that the time characteristic for eddy formation is too short compared to the relaxation time of the polymers. Moreover, he thinks that association of the polymers into aggregates and the effect these aggregates would have on eddy formation has not been given sufficient consideration. It is generally thought that association would be unlikely at the low polymer concentrations normally involved in drag reduction. However,

Cox argues (and has shown from solution viscosity measurements and electron microscopy) that the drag reduction polymers do form small molecular aggregates at low concentrations. He also suggests that the flow pattern within an eddy may actually promote aggregation. To support his argument, Cox is looking at the drag reduction effectiveness of polymers or polymer combinations with strong tendencies to associate.

In the Physical Chemistry Section, Dr. J.A. Hyde, in collaboration with Richards, is using photocorollation spectroscopy to study detergent solutions. Specifically, they are examining mixtures of anionic and cationic surfactants which form gel structures. One peculiarity of these gels is their elastic response at low shear rates. If a flask containing the gel is swirled gently, the entire mass rotates. At higher shear rates the gels are viscoelastic.

Dr. D. Sherrington, also in the Physical Chemistry Section, conducts the principal organic synthesis work of the Department. Currently much of his work is devoted to preparing peptides, saccarides, and oligonucleotides. One of his favorite projects is to try to graft cyclopentadienyl transition-metal compounds onto polymeric carriers. If the metal ions retain their catalytic activity, then the polymer-supported material would be a much less expensive catalyst than the pure metal catalysts now in use.

We visited Dr. J. Ferguson in the Department of Fibre Science; he is very much involved in polymer research, and works closely with the people in the Department of Pure and Applied Chemistry. Ferguson has a wide range of interests, most of them related to the formation of polymeric fibers but also to the general rheology of polymer flow. He has synthesized polyurethane block copolymers with a wide range of hard/soft block ratios, and is determining how this ratio affects their fiber formation by wet spinning. Indeed, much of his work has dealt with the rheology of fiber-forming processes, especially the role of elongational flow. Ferguson has developed an elongational flow viscometer [*Trans. Rheol. Soc.*, 20, 265 (1976)] which is now a commercial instrument about to be marketed. With all the problems of getting an instrument into the scientific marketplace behind him, Ferguson is able to turn his attention to two new problems. He is looking into the kinetics of "template" polymerization which is the mechanism by which sheep grow wool. This seems a reasonable activity for a Scottish university. Also, he is investigating nonpetroleum sources for fibers, specifically cellulosic materials. This work is being done jointly with Courtaulds, Ltd. (London).

Although the greater part of North's time is taken up by administrative duties, he carries on the research on relaxation phenomena in polymers for which he is so famous. In the 1950s North was working on radical-radical reaction mechanisms in polymer systems and became aware of the paucity of data on the molecular mobility of polymers. Since then he has devoted himself to "an experimental assessment of the physical significance of molecular motion in polymers," and has been a pioneer in using various techniques to study relaxation, including dielectric, ultrasonic, and luminescence measurements.

It is instructive to consider why the two laboratories should have such similar research interests. It probably reflects the desire in both groups to take advantage of new techniques and new scientific and technical research opportunities. The recently developed SANS and photocorrelation spectroscopy along with advanced NMR open new avenues of research in polymer and surface science. New scientific opportunities have developed in simulating biological systems, polymer gels and liquid crystals, and polyelectrolytes largely because of health-related needs and dwindling oil supplies. (Willard D. Bascom)

STEEL RESEARCH CENTERS IN PARIS AND ROME

Several European countries now have national metallurgical laboratories. These have mostly been created in support of the steel industries in the respective countries, but often have a scope that includes research on other metals as well. Laboratories of this sort now exist in France (Institute Recherche Siderurgie Francais-IRSID, near Paris); Italy (Centro Sperimentale Metallurgico-CSM, near Rome); Germany (Max-Planck-Institut für Eisenforschung, Dusseldorf; Belgium

(Centre des Recherches Metallurgiques-CRM, Liège); Great Britain (British Steel Corporation Research Laboratories, Sheffield); and Spain (Centro Nacional de Investigaciones Metalurgicos-CENIM, Madrid). I recently sampled the research activities of this kind of laboratory by visiting the IRSID center near Paris and the CSM center near Rome; research programs at CENIM in Madrid were summarized in an earlier note by Klick and Bernstein (*ESN* 32-11:377).

IRSID is located 20 km from the center of Paris, in the western suburb of St. Germain-en-Laye, the former French headquarters of both the German and Allied forces during WWII. This laboratory, established about 20 years ago, is the central IRSID laboratory for physical metallurgy research and development; another in Maizieres-les-Metz, in the northeast sector of France, is more concerned with large-scale process metallurgy development (casting, rolling, etc.). The director of the Paris lab, Dr. A. Constant, reviewed the programs for me, and I had the opportunity to tour the very fine facilities and to discuss specific research programs with a number of the staff.

Research in St. Germain-en-Laye is centered on practical problems of control, measurement, and analysis. The aim is to understand mechanisms to the extent that this leads to control of phenomena of importance regarding properties of steels; one of the laboratory's primary roles is to provide information to steelmakers to improve the efficiency and results of their manufacturing processes.

Several recent developments in steel technology, mostly pioneered in the US, are now taking hold in Europe and are having a strong influence on the direction of research at laboratories such as IRSID and CSM. These developments include continuous casting, inclusion shape control through alloying for high-strength steel sheet, the AOD (argon-oxygen decarbonization) process (especially for stainless and specialty steels), vacuum melting and remelting procedures, and surface coating for corrosion resistance. These developments are much more sophisticated than the old classical methods; and although they lead to much improved properties, they require close control in order to maximize their effectiveness.

The mission of IRSID is determined by a committee composed of the technical directors of the various participating steelworks; this committee meets three or four times a year to review the existing programs and suggest new directions. However, unlike some other national labs of this sort (e.g., CRM in Belgium), IRSID retains a considerable autonomy with respect to research directions, nominally having the right to put 25% of its budget into research of its own choosing.

There are approximately 600 people in IRSID, 1/3 with university degrees. The St. Germain lab is divided into 5 branches: Properties of Steels I (M. Grambach), where the main thrust is high-temperature phenomena; Properties of Steels II (G. Sang), where the emphasis is on mechanical testing and phase transformation; Physical Metallurgy (G. Henry), working mainly on microstructural and substructural analysis; Corrosion and Surfaces (J. Manenc), with an inclination to work on coatings and protective formation for corrosion resistance; and Nondestructive Testing (J. Dumont-Fillon). In an attempt to cross-fertilize the branches, research themes are set up for 1 to 2 years. Each theme group is led by one of the scientists and comprises members of every branch. Current "*thèmes de recherche*" include Hot Rolling, Precipitation Processes in Pipeline Steels, Boron in Steels, Inclusions, Welding, Hydrogen Influences, Quantitative Metallography, and Corrosion-Resistant Steels.

For example, Dr. B. Thomas works in the Physical Metallurgy Branch and heads the theme group on Precipitation Processes in Pipeline Steels. Thomas is an Australian who stopped off in Paris on his way to England to study, more than 10 years ago. Most of his interesting work involves transmission electron microscopy (TEM) and light optical microscopy studies of precipitation and second-phase growth processes. Recent studies include the mechanisms of creep life improvement in boron-doped steels, temperature and alloying effects on stacking fault energies in stainless steel, and properties of bainitic steels. In the last-named study, an attempt is being made to find some material parameter that can be used as a measure of properties in bainitic steels, in the same way that grain size can be used for pearlitic steels, in which the structure is not so fine in scale.

Dr. Gerard Bernard heads another theme group that is interested in weldability and fatigue of HSLA steels. There is particular interest in the effect of steel composition on the mechanical integrity of these alloys. A new approach has been developed to characterize the properties of weld heat-affected zones, the critical regions of the microstructure. Ideally, knowledge of the complete continuous-cooking transformation diagram together with the thermal history of various regions during welding would be most helpful. In practice, IRSID researchers have been able to utilize a very simply obtained indicator, the hardness of the welded regions, to predict integrity. At the same time, they have developed a time-temperature parameter that effectively accounts for the integrated effects of the thermal history. This work is intended to get some of the black magic of welding.

In the Corrosion and Oxidation Group, headed by J. Manenc, J.C. Charbonnier and co-workers have been looking at the influence of molybdenum on the corrosion behavior of ferritic stainless steels in organic acids (e.g., HCOOH) at elevated temperatures (e.g., 70°C), with potential application in the food industry, using electrochemical methods (polarization curves) and ordinary weight-loss measurements.

A tour of the laboratories showed them to be very well equipped. The most impressive equipment is a programable hot-torsion testing facility, which is being used to study, for example, precipitation during extensive deformation. This is important because of the desire to control steel microstructures resulting from hot-working processes. Excellent computer application was noteworthy throughout the IRSID labs, as for image analysis in microscopy and x-ray diffraction texture analysis. The TEM and scanning electron microscope (SEM) have excellent analytical facilities associated. Magnetic domains are studied in the SEM. There is also ion probe equipment. On the processing side, there are facilities for vacuum induction melting, hot and cold rolling, heat treatment, extrusion, deep drawing, stamping, etc. An interesting radiation heating dilatometer, which allows very rapid heating and cooling, is used for phase-transformation studies.

CSM, 20 km south of the center of Rome, is only half as old as IRSID. A total of about 500 persons comprise the CSM staff, compared to IRSID's 600 at both sites. About 90 of the 500 have university degrees. At its single site, CSM carries out the same wide range of work, from basic laboratory studies to pilot plant operations, that IRSID accomplishes at its two sites in France. And as at IRSID, CSM carries out mainly research that is of direct technological interest to its member companies. However, a certain proportion of effort is acknowledged to be assigned for "oriented" basic research, where general scientific conclusions may be drawn from the specific problem-oriented work. In addition to the usual range of laboratory-scale research equipment, the site provides a series of pilot-plant setups including three-high and two-high rolling mills, a 200-ton extrusion press, an experimental line for surface treatments, and a heat-treatment shop. There are also several large-scale test facilities, including 500-ton and 4000-ton compression rigs for structural elements, a large diameter pipe-bursting test station, etc.

The center is divided into four divisions: Casting, Refractories, Computers, and Materials. I visited the last-named which is headed by Dr. G.D. Odone, has some 200 people, and is divided into four main sections: Metallography, Corrosion, Stainless Steels, and Fracture Mechanics. This division is responsible for developing new steel alloys, improving existing alloys, and developing new methodologies for testing and analysis. These are essentially the same aims as at IRSID.

A great deal of research work is being done on new types of HSLA steels for plates and hot strips intended for use in the manufacture of welded pipes, new structural shapes, etc. Research in the field of cold-rolled products is centered on soft magnetic steel strips and deep drawing sheets. In the latter case, efforts are directed to the development of new manufacturing techniques, connected with continuous annealing, and of new types of steel that will be more suitable for these treatments. The group entrusted with advanced physical metallurgy research has been conducting a systematic study of the properties of ferritic steels

with very low carbon content and acicular microstructures; these alloys have high promise for applications requiring very tough high-strength steels. Dr. Val Faccenda, Head of the Metallography Section, showed me the extensive equipment for quantitative metallography, including a Quantimet 720, Philips 400 SEM with EDAX energy-dispersive x-ray spectrometer, JEOL 200 TEM, Cambridge Mark II SEM, Seimens 125 TEM and Camico microprobe.

The Physical Metallurgy Group is also investigating creep phenomena and problems associated with the ductility of steel at low temperatures. Considerable effort is also devoted to the development of advanced types of thermomechanical and heat treatment and to the manufacture of mill rolls (both conventional and clad by means of the electroslag technique). Particular attention is being paid to tribological (wear) problems in connection with plant maintenance. There are long-range programs in fracture mechanics for the investigation of the propagation of ductile fracture, particularly in steels for welded gas pipelines. Also, they are working on safety criteria for large welded structures, with the object of determining more rational design codes. Full-scale tests and advanced test methodologies, *e.g.*, acoustic emission, are being utilized.

The Corrosion and Surface Protection Group covers a wide range of problems. Among the more significant projects are the development of a new electrolytic pickling method using a neutral solution, and the realization of a new group of ferritic low-interstitial stainless steels. In addition, efforts are devoted to the study of metallic coatings and to problems associated with steel structures for marine use. Site tests can be carried out at various land exposure stations for different types of atmosphere and at a marine station in Latina for salt-water exposure. Dr. Bruno Memmi, Head of the Corrosion Section, was trained at Columbia University. His group is emphasizing three areas: stainless steels, accelerated corrosion tests, and pickling. CSM researchers have pioneered in the technique of nonacid electrolytic pickling.

The process of "pickling" in its classical form involves dipping steel in an acid solution in order to remove the surface oxide scales that have formed during hot rolling and heat treatment. In the case of stainless steels, the scales formed have complex structures because of the high oxidizability of chromium. The scale develops as a series of stratified layers consisting of Cr- and Fe-rich layers on a markedly Cr-depleted base alloy surface. The extent of the Cr depletion beneath the oxide scale depends on the temperature and time of heat treatment. This depleted layer plays a dominant role in the pickling process, as descaling proceeds via dissolution of the Cr-depleted alloy supporting the overlaying oxides. Because the final cold-rolled stainless steel products achieve their maximum passivity (i.e. resistant to corrosion) when the less-resistant low-Cr layer is completely removed, the pickling process actually has two important roles for stainless steels: descaling proper, and restoration of the full Cr content at the surface. Potentiostatic pickling offers far better control over the quality of the treatment, which is particularly important for this class of steels. Furthermore, electrochemical control during descaling treatments allows an increase in the rate and efficiency (minimum base metal loss and increased solution life) of the process. The patented working principle of the potentiostatic technique lies in maintaining the potential in the range where anodic dissolution of the Cr-depleted sub-scale layer is kinetically favored.

Researchers in the Corrosion Section have recently been working on the development of new galvanized coatings for use in aggressive environments. This is systematic work intended to evaluate two main factors: the appropriateness of the coating in relation to the environment in which it is to be used; and the ability to produce a homogeneous and adherent coating by reaction with a properly prepared ferrous substrate. The research tends to approach these two aspects separately. In the first case, the corrosion mechanisms are studied for the various coating/environment combinations of interest; the other aspect of the work is complementary to this, and includes studies of the coating structure, the chemical stability of the alloy layer, and the mechanical properties of the composite.

Steels are the most important class of alloys in the world. As such, they are also undoubtedly the most researched alloy group, and have been for many years. Given these facts, one might expect the "research" to be a bit mundane, a bit boring, a bit routine. In my opinion, only a small proportion of the work can be categorized in this way. Certainly there is always a fraction of effort given to what might be called "supportive" research, i.e., in maintenance of normal steelmaking operations. And there are always going to be, in research efforts strongly connected to commercial plant operations, influences that are driven by expediency and therefore tend to abbreviate research from full-scale investigations to problem-solving exercises. Nevertheless, there is still an appreciable amount of effort expended that can be counted toward the advancement of basic scientific principles, if indeed metallurgy can count itself as a basic science at all. Suffice to say that the research workers whom I met in labs such as IRSID and CSM were every bit as qualified and aware in the scientific sense as those at the most fundamental research establishments that I have visited throughout Europe. It is perhaps ironic that they are using the latest in research methodologies and the most advanced knowledge in metallurgy in order to work on the world's most common man-made material. (Jeff Perkins)

NOTE: Research progress in Europe on steel welding problems was reviewed in a recent note (*ESN* 33-4:156), while HSLA steel developments were covered in *ESN* 33-7:289.

MEDICINE

AMERICAN-IRISH RADIOLOGY SYMPOSIUM

"By the Killarney's lakes and fells" is the opening line of an Irish ballad, which scarcely does justice to the magnificent southern Irish countryside. Hotel Europe, situated on the shores of Lough (lake) Leane in Killarney was the site of the American-Irish Radiology Symposium. To combat the possibility that the splendor of the scenery might be too great a distraction, one of the two daily sessions was held in the morning and the other in the evening, leaving the afternoon free to golf, fish, hike, or just walk about, while the absence of any night-life made an evening session quite tolerable.

The symposium commenced with a discussion of radiographic contrast media, which are now undergoing significant changes for the first time in three decades. Ronald G. Grainger (Hallamshire Hospital, Sheffield, UK) delivered a paper concerned with water-soluble contrast myelography, a particularly appropriate subject for the mixed European and American audience. Until the development of Pantopaque in 1944 all contrast materials were too toxic to be introduced into the spinal canal. Pantopaque, because of its oil base, is not soluble in cerebrospinal fluid and has several well recognized disadvantages: 1) it does not fill nerve root sleeves, 2) it frequently breaks up into oily droplets, 3) it is absorbed from the spinal canal very slowly if not entirely removed, and 4) there is good histological evidence that it results in chronic arachnoiditis. Although the chronic arachnoiditis can be demonstrated in experimental animals or at autopsy, it was not until recent years considered a significant clinical problem. However, because of it, Sweden in 1972 took the lead and refused to permit an oil-based contrast material to be injected into the spinal canal. This induced vigorous attempts to perfect a water-soluble contrast material of low toxicity. A compound with an entirely new structure resulted, a water-soluble, non-ionic, substituted amide of metrizoic acid, metrizamide. Although Pantopaque is still the standard in the US, it has been largely replaced in Europe by metrizamide. It has the advantages of low toxicity, low osmolality, and sufficient iodine for contrast purposes. It has a number of other clinical advantages as well: the entire nerve root sleeve can be seen; under ordinary circumstances it does not have to be removed from the spinal canal; no local anesthesia is necessary prior to injection because of low viscosity, a small needle can be used; and tomography can be employed to good advantage. There are a few disadvantages: because of rapid dispersion the exam must be made rather quickly; as an increase in side effects

has been noted, the contrast should not be allowed to run into the head; and the cost is high. The usual side effects of headache, nausea, and vomiting are not severe. The only significant complications are seizures, reported in 22 of 5500 myelograms. In most of those cases, however, other reasons for seizure activity were also present. Histological examination of animals following metrizamide injection has yielded virtually no arachnoiditis.

Although in use in Sweden since 1972 and in the UK since 1974, metrizamide was not passed by the American Food and Drug Administration until November of 1978. Early users reported excessive toxicity but this was dose related and, if one considers the Swedish and British experience, the reason for the delay by the FDA is not clear. However, the advantages of metrizamide over Pantopaque are considerable and its increased use in the US is now expected. Grainger emphasized, however, that there are technical differences in carrying out Pantopaque and metrizamide myelograms, which have been well outlined in the radiological literature.

"Air Myelography in Spinal Dysraphism," by James Toland (staff radiologist, Richmond Hospital, Dublin, Ireland), was interesting in that the author had collected 100 cases of obscure spinal congenital abnormalities. Toland demonstrated the diagnostic features of these anomalies with air myelography and also with CT (computerized tomography) metrizamide studies. In many cases the filum terminale of the spinal cord is adherent to the abnormal bone, and surgery must be carried out to prevent additional neurological deficits. In regard to the best method of examination, the author feels that air myelography with tomography or with CT is preferable.

A paper by Joseph T. Ennis (Mater Misericordiae Hospital, Dublin, Ireland) was an overview of recent developments in the study of cardiac disease using radioactive isotopes. The speaker was well prepared and had excellent material, although it was excessive for a 30 minute presentation. His talk was divided into three sections: 1) the detection of acute myocardial infarction, 2) detection and localization of intracardiac shunts, and 3) the assessment of left ventricular perfusion and function. In the first part Ennis described and illustrated the mechanism for the uptake of ^{99}mTc pyrophosphate in the damaged cardiac muscle. As pyrophosphate is a calcium seeker it is taken up by the necrotic cardiac muscle along with calcium salts in the healing process. The advantages of the isotope study are: 1) early diagnosis, 2) diagnosis of a silent infarct (normal EKG), 3) differentiation of a new infarct from an old one and, 4) quantification of the infarct. The study has limitations in that there will be false positives if the valves of the heart are calcified, or if a ventricular aneurysm, unstable angina, or contusion following cardioversion is present.

In the second part of his talk, Ennis showed how a radionuclide study can act as a screening procedure before cardiac catheterization. In patients with intracardiac shunts, an echocardiogram should be the first step after detection of the murmur, followed by the isotope scan. ^{99}mTc technetium pertechnetate is injected and, if it is detected as it recirculates through the lungs, an intra-cardiac shunt is probably present. Patients can then be selected from this group for cardiac catheterization.

In the third part of his talk, Ennis described how stress and rest scans with an isotope of thallium, (^{201}Th) are used to estimate myocardial perfusion, important in selecting patients for by-pass surgery. The left ventricular ejection fraction can be measured as well as regional ventricular wall motion and left ventricular velocity. To facilatate analysis of left-ventricular function under stress, multiple-gated acquisition studies (Mugx) have been tried. Erythrocytes are labeled with ^{99}mTc, and the scintillation camera is gated and synchronized with the R-wave of the electrocardiogram. The camera is opened at end-systole and at end-diastole so that the ventricular wall can be studied at specific times of the cardiac cycle. The isotope counts are fed into a computer that produces a visual outline of the left ventricular wall. Current experiments using this same technique are now being carried out to measure the effects of drugs such as digitoxin and beta blockers.

Anthony Lalli (Cleveland Clinic, Cleveland, Ohio) described his experience with aspiration needle biopsy of the lung in more than 1500 patients.

There were 1033 true positives and 309 true negatives, better than 85% overall accuracy. The greatest sources of errors were 188 false negatives for the diagnosis of carcinoma. Significant complications to this procedure are quite rare, but a moderate number of patients did suffer a pneumothorax following the needle biopsy. Since many of the needle biopsies were carried out on an out-patient basis, Lalli and his group decided to treat the small pneumothoraes on an out-patient basis as well. This is done by inserting a small tube into the pleural space, connected to a Heimlich valve taped to the patients chest wall. He or she is then asked to return for additional radiographs every few hours. Usually within 24 (or at the most 48) hours the tube is removed. The success of aspiration needle biopsy and the low complication rate make it a critical diagnostic procedure for patients with a lung mass. It saves unecessary surgery; but the false negative rate indicates that some patients should be operated on even if the aspiration biopsy has failed to diagnose neoplasm.

Among the highlights of the meeting were two talks on contrast media and adverse reactions. The first, another delivered by Grainger, dealt with the significance of osmolality. Initially Grainger listed three types of contrast reactions: 1) anaphylatic, 2) chemotoxic, and 3) osmolar. Intravenous contrast materials, the sodium and meglumine salts of substituted benzoic acid, in use for the past 30-35 years are 5 times the osmolality of blood plasma. The adverse effects of increased osmolality include: 1) vasodilatation, 2) red blood cell shrinkage and crenation, 3) blood-cell sludging, 4) osmotic hemodilution, 5) hypervolemia, and 6) increased permeability of capillary endothelium. Grainger again discussed the advantages and disadvantages of metrizamide and then went on to describe current work being carried out on Dimer X, a two-benzene-ring-molecule in which one of several carboxyl groups is replaced by the sodium or meglumine cation. This compound, sodium or meglumine ioxaglate (Hexabrix), should be much cheaper than metrizamide, have an osmolality very close to blood plasma, and cause less pain at the injection site.

The second talk on contrast material, "The Contrast Media and Death," was also delivered by Lalli. He had the unique opportunity of investigating 228 contrast-medium deaths in the US. The data released to him by the three major drug companies had been collected by them over the past ten years. The death rate for intravenous urography is one in 40,000 patients, and is 8 times greater in intravenous cholangiography. The latter study is, however, being rapidly replaced by CT and ultrasound studies. Lalli thoroughly investigated all the clinical and autopsy data relating to the 228 deaths. Previous proposed explanations have been: 1) allergy, 2) protein-binding, 3) hemodynamics, 4) complement consumption, 5) excess free iodine, 6) histamine release, 7) cholinesterase inhibition. The latter two relate only to intravenous cholangiography. The patients suffered a marked variety of reactions, including cardiac and respiratory arrest, seizures, loss of consciousness, chills and fever, leading to death. At autopsy some were found to have had pulmonary edema or myocardial infarction, while in others nothing abnormal was found. Except that they all had had contrast material, there seemed to be no common denominator. Lalli's hypothesis is related to the central nervous system and is the only one, he contends, that can relate all the contrast deaths not due to overdose. Because the blood-brain barrier is incomplete near the hypothalamus, the reactions could be due to the contrast entering the hypothalamic area of the brain, causing either a marked sympathetic or parasympathetic response. A sympathetic response, for example, could lead to cardiac fibrillation and sudden death, and at autopsy the heart would be normal. On the other hand a parasympathetic response may lead to bradycardia and bronchospasm. Lalli also believes that fear of death during the injection plays a role in those patients who have a severe sympathetic or parasympathetic response.

Lalli found, by experimenting with mice, that hexamethonium, a sympathetic blocker, will prevent death from contrast material in the mice and will increase the LD_{50} dose. Of even greater interest, he found that Valium worked in a similar manner to hexamethonium, blocked the sympathetic re-

sponse, markedly increased the LD_{50}, and prevented a number of deaths in the mice. Because the work is so new, Lalli is hesitant at this time to make any recommendations; however, he is using Valium with some patients at the Cleveland Clinic.

Three papers were delivered on the state of the art in ultrasound, CT scanning, and nuclear medicine respectively. Ultrasound, by K. Taylor (Yale Univ. School of Medicine, New Haven, Conn.), dealt with two technical breakthroughs in the past several years that have led to vastly increased usage of ultrasound, gray-scale imaging and real-time imaging. Gray scale allows for visualization of organ substance, not only acoustical borders; and real-time imaging allows for ultrasonic reproduction of motion.

The state of the art in CT scanning was discussed by Joseph T. Whalen (Cornell Univ., New York, NY). Whalen outlined the various modalities available to a department of radiology and then addressed himself to the essence of the problem; the order in which the studies should be used to screen a patient for a specific medical entity. The New York Hospital has had considerable experience with CT scanning and ultrasound as well as the older modalities. Based on data gathered over the past five years, flow diagrams were developed, soon to be published, that will be of great help to smaller institutions. The assistance and savings in time and money they will provide cannot be overestimated.

The state of the art in nuclear medicine was described by Richard P. Spencer (Univ. of Conn., Hartford, CT). Spencer's major point was that nuclear medicine cannot compete with radiographic and ultrasonic images and must increasingly turn toward functional examinations. Because of an increased metabolic rate in inflammations or tumors, isotopes such as ^{67}Ga can be used to localize tumors or infections that are either too small or to early to be seen by radiography. Nuclear cardiology will be important in ejection-fraction determination as well as hot-spot scanning for myocardial infarctions. In the newest area of positron emission, metabolites (not only amino acids but also carbohydrates and lipids) can be tagged with a positron emitter for metabolic survey studies. At this time, however, these studies require a cyclotron. (Irwin M. Freundlich)

CYSTOURETHROGRAPHY IN CONGENITAL ANOMALIES OF THE LOWER URINARY TRACT

The use of retrograde cystourethrography in the evaluation of congenital anomalies of the lower urinary tract has been controversial. One of the major obstacles to a uniformity of opinion has been the absence of a large series of patients examined by this modality. The work currently underway at the Chaim Sheba Medical Centre, Tel-Hashomer, Israel, should eliminate further doubts about the procedure. Prof. Marjorie Hertz and her group have completed a study of 110 male infants with hypospadias and 21 female infants with fused labia. Their findings in this large group will be of considerable importance in the further understanding of these uncommon conditions.

Hypospadias, a congenital anomaly of male infants, consists of defective closure of the urethra that results in an aberrant location of the meatus, proximal and ventral to its normal position. It has been classified or graded, according to the site of the meatus, as glandular (the least severe), penile, penoscrotal, and perineal. This anomaly actually represents incomplete masculinization of the external genitalia and may be accompanied by other genital as well as urinary-tract anomalies. Most cases require surgical correction. In the female infant a much more unusual and less severe an anomaly is fused labia, a condition of partial or complete adherence of the labia minora in pre-pubertal girls. While it may be asymptomatic, voiding difficulties and urinary tract infections have been reported.

For a better understanding of hypospadias the embryological development of the lower genito-urinary system is reviewed briefly. In the 8th week of embryonic life the labioscrotal swellings lateral to the phallus move caudally and form the urethral folds. Fusion of the urethral folds is from the base toward the tip of the phallus, and it is in this way that the urethral groove is covered. Should the urethral folds be arrested during this process of closure, hypospadias results. The severity of the condition depends upon the time fusion is arrested. In penile hypospadias, a fibrous band between the meatus and the blind dimple on the penis causes shortening and a downward curvature, a condition known as chordee.

In the more severe penoscrotal and perineal hypospadias there is often associated maldevelopment of the gonads with a deficiency of masculinizing hormonal influence. Because of this deficiency the Mullerian duct structures (female) fail to regress while the Wolffian ducts (male) fail to develop fully and completely. It has been previously shown that the severity of the hypospadias can be correlated with the size of the Mullerian duct remnant.

The technique used at the Chaim Sheba Medical Centre for performance of retrograde cystourethrography is straightforward. It is carried out by radiologists under sterile conditions with fluoroscopic monitoring. A soft rubber catheter is introduced through the urethra into the bladder: 100 to 200 ml of water-soluble contrast material is infused until the patient feels the urge to void. The contrast material should be of a relatively low iodine density, for example, 30% sodium diatrozoate. A radiograph of the full bladder is made prior to withdrawal of the catheter. In patients old enough to stand, the table is then put into a vertical position and the patient voids into a container. During voiding, radiographs are made of the bladder and the urethra in an oblique projection and finally a radiograph is made after micturition is complete. In children too young to stand the examination is carried out in the supine position.

The retrograde cystourethrogram visually demonstrates the extent of the anomaly and is now considered a mandatory pre-operative procedure by the group at the Chaim Sheba Medical Centre. Several radiological changes are of importance: 1) A widened urethra indicative of a functionally significant meatal stenosis (conversely, a normal urethrogram in the presence of a meatus that seems strictured on physical examination excludes a functional stenosis), 2) the precise position of the meatus, 3) the presence and size of a Mullerian duct remnant, 4) vesicoureteral reflux, 5) the location and size of the fistulous track to the perineum that develops in cases of complete meatal stenosis. In addition, a pre-operative examination is very helpful for comparative purposes in cases of post-operative complications.

Forty-nine of the 110 patients studied by Hertz and her group were under one year of age, while another 41 were between the ages of 1 and 5. The cystourethrogram was considered abnormal in 65 of the 110 patients. The most common abnormality was meatal stenosis found in 38. However, the presence of meatal stenosis was not related to the grade of abnormality.

The Mullerian duct remnant was demonstrated in 11 of the patients. In all of these cases the meatus was located in the penoscrotal or perineal region. This figure may be higher, as the Mullerian duct remnant is best demonstrated if the external urethral orifice is compressed. Compression, not carried out in all cases, results in backflow of the contrast into this structure. If the Mullerian duct remnant is elongated and located distally, it assumes a more vaginal appearance.

Reflux of contrast material from the bladder into the ureters was found in 14 patients, 10 of whom were asymptomatic but 4 had unsuspected urinary tract infection. Because of this all patients are now treated with an antibiotic before surgery. Patients undergoing surgical correction for hypospadias often develop complications—as many as 40% in one series has been reported in the literature. The pre-operative cystourethrogram, therefore, is of considerable importance for comparison if a post-surgical complication does develop.

Previous studies indicate that there is a significant association be between anomalies of the upper urinary tract and hypospadias. The kidneys ascend and rotate during the 6th and 7th embryonic weeks, which is somewhat earlier than the development of the urethra. However, there is some temporal overlap, and it is probable that the development of the kidneys and the urethra are influenced by a common factor that results in the high incidence of associated anomalies. Hertz and her group carried out routine intravenous urograms in each of their 110 patients and found anomalies in 50. The most common was malrotation of the kidney discovered in 32 patients, but in no case was it severe enough to cause hydronephrosis. Ectopic kidney was seen in 4 patients and a double collecting system in 3, 2 of whom had vesicoureteral reflux. Hydronephrosis was found in 6 patients.

The pre-operative cystourethrogram has proven so valuable for children with congenital anomalies that it is

now a mandatory pre-operative procedure at the Chaim Sheba Medical Center.

In caring for their civilian and military patients, Hertz and her group are studying additional uses for the retrograde cystourethrogram. One of these, in an early stage but of considerable potential importance, is the examination of neurogenic bladder in soldiers with spinal injuries. The combination of a large number of patients concentrated in one area and an enthusiastic group of radiologists has proved beneficial particularly to children with congenital anomalies of the lower urinary tract. (Irwin M. Freundlich)

METEOROLOGY

WIND AND MORE WIND

The UK Royal Meteorological Society held its regular summer meeting 23-24 August at the University of Stirling in Scotland. Local residents are proud to state that the University is the only new one to be established in Scotland in the last 300 years. The government was able to obtain a country estate landscaped with centuries-old trees and containing a meandering man-made 28-acre lake. This setting, about two miles from the city center, in which the University was built about ten years ago, is one of the most beautiful I have ever seen.

The first day's session was on the applications of wind information to structures, vegetation, and aircraft. Three invited papers were presented.

Dr. J.R. Mayne (Building Research Establishment, Watford, UK) spoke on "Wind and Structures." He kept everyone awake by showing dozens of slides of wind damage to all sorts of man-made structures, beginning with the collapse of the Brighton chain pier in 1836. In recent years, large buildings have become more sophisticated and tall buildings now are only 1/3 the weight of pre-WWII structures of equal size. Being lighter, they are more susceptible to wind damage, and so careful studies of potential wind effect are required.

One of the first scientific studies of wind effects was made prior to the construction of the Firth of Forth railway bridge in 1882-1890. An engineer put up two iron plates having respective areas of 1 sq ft and 100 sq ft, and actually "weighed" the wind force on the two plates. He was surprised to find that the maximum gust pressure, 56 lbs/sq ft, occurred on the small plate.

The symposium marked the centenary year of the collapse of the Tay Bridge under the influence of strong winds. Ninety-one lives were lost when a train went down with that bridge. The next bridge failure due to wind occurred when the Tacoma (WA) Narrows Bridge failed in 1940 after only four months of use. Mayne pointed out that the Narrows Bridge had been designed by extrapolation from other bridge designs to save money. By the 1930s scale models of structures were being tested in wind tunnels. However, only in the past 10 years have wind tunnels been available which can simulate turbulence and shear similar to that occurring in the atmosphere. The atmospheric-ground boundary layer can be duplicated to scale.

Electric transmission line pylons are particularly susceptible to wind damage, with an average loss of five a year in the UK. Most buildings which fail in strong winds do so because of differential pressure between the inside and the outsides. Forces due to differential pressure may be up to five times as great as direct wind pressure on the front of a building. Flat-roofed buildings are more apt to be damaged than pitched-roofed ones.

Mayne asked the meteorologists present for more and better wind data, although the UK has the best coverage in the world. Observations are needed over at least 30 or 40 years if one is to predict maximum gusts that may be expected at any location.

Dr. J. Grace (Dept. of Botany, Univ. of Edinburgh), spoke on "Wind and Vegetation." An experienced observer can study the shapes of trees in Scotland and come up with a pretty good estimate of wind forces on them. This method is actually being used to study where the best places are for wind power generators.

The wind distribution on mountains determines the plant communities that will grow there. If a wall is placed on a mountain to act as a windbreak, a new community of plants will grow

on the leeward side of the wall. Not only does a windbreak help prevent mechanical damage to plants, but it also slows down evaporation from plant surfaces.

The fluxes of heat, oxygen, and water vapor from a leaf are functions of the turbulence and wind speed around it. Some leaves have hairy surfaces to provide a dead air zone to cut down on fluxes of heat and water. Botanists have developed a range of tiny instruments to measure temperature and evaporation rates of different kinds of leaves; such research may help to answer the age-old question about why leaves come in so many different sizes and shapes.

The paper was followed by a lively discussion from the audience on the problems of "blow downs" in forests in Scotland. Many mountainous areas with thin and poor soil are being reforested. The forests are thinned for pulp wood and to allow the remaining trees to grow more rapidly, but this thinning greatly increases the number of trees that are blown down. Another unexplained phenomenon occurs when a patch of trees well away from the boundary of a forest is blown down in mass. One hypothesis is that this is caused by mini tornadoes.

The last invited paper in the symposium on wind, "Wind and Aircraft," was given by Dr. M.J. Dutton (Meteorological Office, Bracknell, UK). His office makes climatological site studies for potential airfields sites in the UK, with emphasis on the frequency of winds of various speeds and directions. The upper limit of cross wind that is acceptable to large commercial aircraft is about 25 to 35 knots. Cloud cover is also a factor in selection of an airfield.

Dutton's own speciality is the effects of low-level shear on aircraft. He defined surface shear that affects landing and takeoff as extending up to 100 ft from the surface, and low-level shear that affects approach and climb-out as extending from 100 to 2000 ft. At the present time operational forecasts given to pilots for a landing or take-off are ten-minute averages. Dutton believes that the averaging period should be shortened to 1 to 2 minutes, because of the rapidity with which wind characteristics can change near the ground under turbulent conditions.

Dutton discussed turbulent pseudo-random fluctuations about the mean wind with periods between 0.1 and 2 sec. Turbulence has little effect on large commercial aircraft because it tends to average out over the large area of the plane. He defined "wind shear" as variations in speed or direction with durations of 5 sec to one minute. This is long enough to cause deviations in the glide path of large aircraft. Accidents frequently occur when the pilot over-corrects. Jets are particularly vulnerable because it takes from 2 to 6 sec to make a change in power (i.e., the planes just do not react fast enough) and because they are heavier and faster.

Some of the sources of shear (as here defined) that have damaged aircraft are: (1) vertical wind shear in both direction and speed across a stable layer, (2) low-level jet phenomena under an inversion at night, (3) line squalls, (4) cold fronts, (5) long-wave-length turbulence in strong winds, and (6) down-wind shelter effects from airport buildings. The first two listed are bad because the pilot does not encounter warning turbulence prior to the shear taking effect, and his senses are lulled. It is interesting to note that England has not had any accidents caused by shear for the past ten years; unfortunately, most of the examples are from the US. However, some planes on the ground at Heathrow have been blown together by gusts. A close call came when a plane encountered a von Karmen vortex in a cross wind that had been caused by one of the main terminal buildings.

Shear is extremely hard to predict; we have no operational method available to measure downdrafts which are the usual cause of accidents. Frequently shear will be detected over one runway and not over another runway close by.

The second session of invited papers was on meteorological aspects of energy resources.

One of the most interesting and thought-provoking papers was by an engineer, A.W.M. MacGregor (Napier College, Edinburgh) who spoke on solar energy and internal climate of buildings. He pointed out that

many of the more elaborate systems to utilize solar energy are simply not cost effective. (See *ESN* 31-4:163 and 33-5:181.) Then he discussed a whole series of minor, less expensive things that one can do to conserve energy, such as use of dark-colored exteriors, smaller and double-paned windows, insulating drapes, adding a solarium to the sunny side of the house, etc.

Mr. S. Lamming (Carribean Meteorological Institute, Barbados) spoke on the "Potential for Wind Generation of Electric Power on Barbados." He had just completed a several-month-long study of the subject at the University of Reading in the UK. He considered economics to be the main factor, and devoted most of his time to it. Barbadoans have become accustomed to using a lot of electric power, all of which comes from diesel generators. Since OPEC raised oil prices, imported oil has become an important factor in the country's economic balance of payments. Using prototypes now in existence, Lamming concluded that wind power was economically feasible for the Barbados. He concluded that wind power would also be feasible in the outer islands of Scotland.

The last invited paper of the session was on the statistics of wave power, by Dr. Denis Mollison, a statistician (Heriot-Watt Univ., Edinburgh). The subject of generating electric energy from wave power is one of continuing great interest in Great Britain (see *ESN* 32-4:124 and 33-10:405). The current annual budget for research on the subject exceeds ten million dollars.

Given a description of sea and swell components in terms of their he heights, periods, and directional spread, wave con''tions for modelling the response of machines generating power from the waves can now be realistically reproduced in sophisticated experimental wave tanks such as the one that was recently built at the University of Edinburgh.

The overall average wave power impinging on the UK is of the order of 30 GW, greater than the UK's average electrical demand. However, the power is so variable that without a very large storage capacity, only about 5 GW could actually be fed into the country's electrical grid. Mollison is optimistic in his belief that eventually wave power devices may be cost-effective for the UK.

This was one of the best meetings I have attended. All of the speakers were given plenty of time. There was a great deal of discussion and hot arguments from the audience. For other articles on wind and wind power, see *ESN* 31-8:302 and 33-10:405. (Wayne V. Burt)

METROLOGY

MEASUREMENT, CALIBRATION, AND STANDARDS

We tend to take for granted knowledge of such things as a pound or a gallon. If we buy a pound of meat we expect it to be a full pound, we expect that somebody knows what a pound is, and we expect that someone has checked the butcher's scale; when we talk about noise reduction, we expect that somebody knows how to measure and define a particular noise level so that regulations may be enforced. Possibly even more taken for granted, and even more important, is the availability of standards for industry, not only elementary standards like those of dimensions (so that parts purchased from different suppliers can fit together) but things like electrical or optical or chemical standards.

An industrialized country must have a central laboratory for these purposes. In the United States it is the National Bureau of Standards (NBS), which is a part of the Department of Commerce. In England it is the National Physical Laboratory (NPL), which is part of the Department of Industry. NBS has about 5000 people against NPL's 1000, and the per capita budget at NBS is about 2-1/2 times as high as at NPL. Partly these differences represent the difference between the countries, partly the fact that NBS has a broader charter. There are other differences. NPL may be somewhat more insulated politically: The Director of NBS reports directly to the Secretary of Commerce; the Director of NPL reports to Dr. Davies, of the Department of Industry, who in turn has two bosses, one of whom is the Secretary of State, a political appointee, while the other is the "Permanent Secretary," who is a civil servant.

"They can play it long." This slang British expression, presumably meaning that the political insulation permits these civil servants to take a long view or carry out long-range planning, was made to me by Dr. Paul Dean, Director of NPL, a PhD in theoretical physics. He came to NPL in 1957 and worked in such areas as phonons in disordered systems (alloys and glasses). In 1967 he became head of the central computing unit, then head of the division of basic standards, and deputy director from 1974-76. He then went to Whitehall as Undersecretary of the Department of Industry for a year, and has been Director of NPL since.

NPL is located on a 60-acre tract at Teddington in Middlesex, some 13 miles from the center of London. The Laboratory was founded in 1900 (about the same time that NBS was founded) and uses some of the old buildings that were already there, including one in which William IV lived before he became king in 1830. The bulk of NPL's budget, something over £10 million, comes from the requirements boards of the Department of Industry, and especially the board on metrology and standards. An additional few million pounds for buildings comes from other government sources, and there is some additional income from fees charged for calibrating instruments and the like.

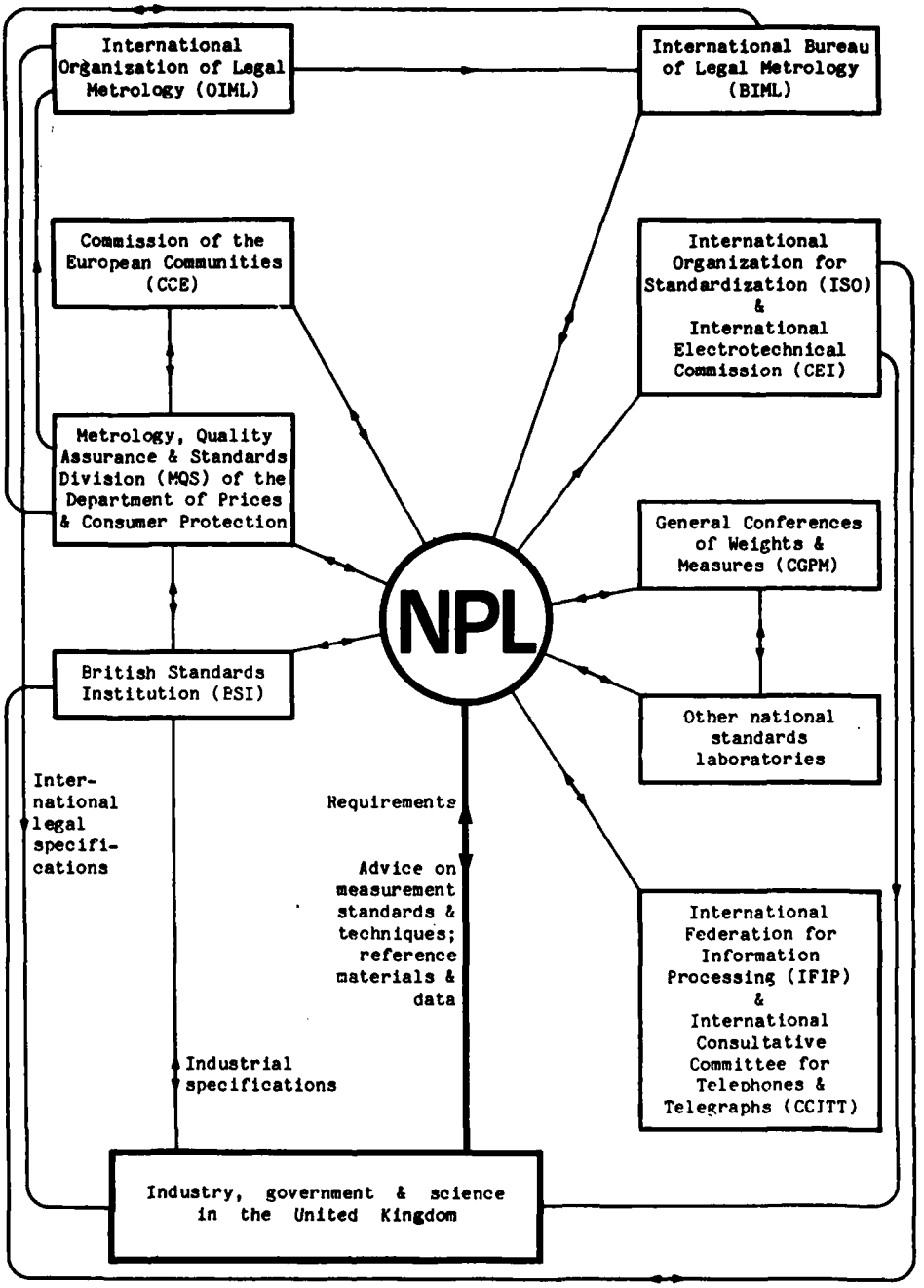
One of the reasons that NPL has a narrower charter than NBS is because it has hived off (again British slang—we would have said spun off) certain functions. The most important of these are the National Engineering Laboratory, some 25 years ago, and the National Maritime Institute, 3 years ago. These have left NPL with considerably less than its maximum staff levels, which were about 1,700 in the mid-60s. Of its remaining principal areas of responsibility, the National Corrosion Service was covered in *ESN* 32-10:329 and computing and numerical analysis in *ESN* 32-4:137. Most of the remaining activities come under the heading of "provision and dissemination of standards" and the British Calibration Service, which are at the heart of NPL's functions, and which are the subject of the present article.

The knowledge and services that NPL provides are fundamental to the specification of quantity, quality, and performance in a wide variety of industries and ensure compatibility both nationally and internationally between the results of all types of measurement factors. Standards are required not only in such fundamental units as mass and length, but also for the specification of materials and systems of a physical and chemical nature. Advances in engineering are imposing continual demands for improved measurement capability, and advances in metrology necessary to meet these demands can take many years to implement.

As indicated in the chart, standards requirements are now emerging to an increasing extent with an international rather than a national framework, and NPL interacts with a number of foreign organizations. However, their evolving program is basically in response to the needs of industry. This is particularly true of traditional areas where NPL's capability goes back many years. Thus the standard of length was originally the kilogram bar in Paris. NPL had a copy of this bar which it used to derive secondary standards which in turn were used to calibrate and monitor the numerous working standards in use on the factory shop floor and laboratory bench. Subsequently this standard was abandoned and various spectroscopic standards were accepted, with accuracies up to one part in 10^7. Now these have been abandoned in favor of laser standards with accuracies of one part in 10^{11}.

In newer areas NPL may exercise its own initiative to develop a capability, and in fact the director is allowed to spend up to 10% of the budget on his own initiative for such things. In fact he has generally spent only 1% or 2%, because, he told me, the boards have always approved any project he wished to undertake out of their money. Because the organization has been getting smaller, it is hard to start new things; but new starts are still being made. For example, about 1974 they became aware of the fact that ultrasonics was being used increasingly in medical diagnosis and therapy and might ultimately replace x-rays for investigations into soft tissue. Since there existed no standards on ultrasonics, they assigned three people to develop a capability, and

The principal links between the NPL and other organizations



are now in the process of actually starting service in this area.

Even an incomplete listing of the areas in which they are active in supplying standards is impressive: hardness, flow measurement, voltage, coaxial power standards for RF and microwave fields, automated equipment for plasma diagnostic measurements, laser power and energy calibrations at 10.6 μm, measurements of ionizing radiation, dosimetry for neutron beams, oil-soluble metal-organic compounds having certified metal contents, measurement of temperatures to 1000°C, excess noise certification, angular measurement (to 0.00001°), etc., etc.

The lower left corner of the chart shows that ultimately these services must be provided to industry, government, and science in the United Kingdom. To a large extent this is done through the British Calibration Service, which was set up in 1966 and has been a part of NPL since 1976. Scientific instruments and other measuring devices can be certified, and the British Calibration Service certificate provides a high degree of assurance of correctness of the calibration of the instrument identified on the certificate. The issuance of such a certificate also indicates that the measurements are traceable to national standards.

It is hard to measure the effectiveness of an organization such as NPL, but it is probably safe to say that without such an organization, no nation can compete in the world of modern technology. (Robert E. Machol)

OCEANOGRAPHY

OCEAN ENGINEERING AT HERIOT-WATT UNIVERSITY

Heriot-Watt College in Edinburgh was founded in 1821 as a school of arts. Later it developed into one of the leading technical colleges in the United Kingdom. It came of age in 1966 when it was renamed Heriot-Watt University by Royal Charter. The University has a long record of achievement in technical education and over the years has developed a close and effective collaboration with industry.

The engineering departments have developed a BSc Honours degree program in the field of offshore engineering with 1st, 2nd, and 3rd class classification. The first two years can be taken in common with other engineering students in one of the following departments: Building, Chemical and Process, Civil, Electrical and Electronic, or Mechanical Engineering. About half the courses in the last two years are in offshore engineering.

When drilling for oil in the North Sea became a reality, the University established the Institute of Offshore Engineering (IOE) to aid the oil companies and the supply industry. The Institute endeavors to meet the need for a coordinated approach to the many R&D problems facing the offshore petroleum industry and its contractors. IOE promotes and manages multidisciplinary research and development projects; provides consultants; organizes seminars, courses, and conferences for senior engineers and managers, usually on highly specialized subjects; and maintains an information service to answer technical inquiries. The subjects of interest are the engineering, scientific, economic, and environmental aspects of offshore operations: oil companies have never had to face conditions as bad as those in the North Sea. To quote Mr. P.B. Baxendell, Managing Director, Shell Limited: "the North Sea environment is unique in its sustained nastiness."

The IOE draws on the expertise of various academic departments of the University, as well as of its own staff in carrying out the objectives listed above. It also offers access to the University's large amount of sophisticated testing equipment.

The Director of the Institute, Professor Tom Patten, is also Professor (Department Chairman) of Mechanical Engineering and Vice-President of the University; the Deputy Director is Mr. J.R. Atkinson. The Institute is largely self-supporting through its contracts with industry and government.

Present instruments are inadequate for the industrial demands of offshore oil exploitation, and one of Patten's personal research interests is the development of the necessary instrumentation technology (including improved subsurface instruments) for monitoring oil-well heads, pipelines, and other equipment in the hostile environment

on the bottom of the North Sea. There are strong tidal currents scouring the bottom, and the effects of long, high sea waves and storm surges are felt all the way to the bottom in parts of the North Sea. Part of the Institute's objective is to develop a system of sensors, transponders, and recorders. Records from as many as a dozen sensors will be stored in the recorder. Periodically the recorder will be interrogated acoustically from a surface vessel or fixed platform. If any of the sensors have recorded significant changes since the previous interrogation, the instrument will report them to the interrogator via coded acoustical signals. If recorded changes indicate the possibility of serious or potential damage, divers or submersible vehicles will be sent down to assess the situation. There are hundreds of miles of pipe up to 36 in hes in diameter on the bottom of the shallow North Sea that may be affected by environmental conditions or by offshore operations.

The largest in-house division of IOE deals with problems in biological and chemical oceanography. The head of this division, Dr. Cliff Johnston, is also a member of the Biological Science Department and directs a program leading to degrees in marine biology. Johnston first acted as coordinator of research for IOE, using staff members from eleven different departments to carry out surveys and research projects. The need for research in biological and chemical oceanography, however, grew so rapidly that he was able to hire full-time staff specializing in these disciplines. IOE purchased its own equipment, including a gas chromatograph-mass-spectrometer. These instruments are used to determine the source (recent natural or fossil fuel) of hydrocarbons found in their samples. (See Copin's work in *ESN* 33-8:333). A large share of the work of this division has consisted of pre-site surveys, both for shore-based oil and gas terminals and for off-shore oil and gas drilling platforms. Although industry supports most of the work done by IOE, Johnston's division receives 1/3 of its funds from the UK Government Research Councils (e.g., SRC, NERC).

Although there are no statutory requirements for environmental impact assessment studies, the oil companies have found out that bona fide studies speed up the process of obtaining permission for construction projects. Johnston is proud of the fact that not a single project that he has worked on has been held up because of environmental problems.

In order to maintain their credibility with the scientific community, Johnston's group publishes its results regularly in scientific journals. The most detailed environmental study was for the Occidental Oil Company's loading terminal in the Orkney Islands north of Scotland. IOE has also done environmental assessment studies on the British Petroleum loading terminal in the Shetland Islands, the liquid petroleum gas (LPG) terminal proposed for the Firth of Forth near Edinburgh, the Amoco-Cadiz oil spill on the northwestern French coast, and a number of oil fields in the UK segment of the North Sea, including the Brent, Auk, and Murcheson Fields.

In addition to the above, IOE has a contract from the SRC to investigate the constituents of oily-water effluents (ballast water and leakage from oil terminals and refineries) and are going so far as to determine trace-metal contents of various effluents. Some of their NERC support is for the study of the natural input into benthic sediments of hydrocarbons from algae and other marine plants.

Much of the research done in the Department of Offshore Engineering of the University is for oil companies and is under the direction of Professor A.R. Halliwell. He and his staff, including D.G. Owen and B.T. Linfoot, have developed a very sophisticated 9 m × 9 m × 1 m deep wave tank primarily for testing models of single-point moorings (SPM). The oil companies have installed over 100 SPM's for oil tankers in many locations in the world. The principal advantage of a SPM is that it allows the tanker to weathervane under the natural action of wind, waves, and current, and thus to minimize the forces acting upon it. Although there is voluminous literature on the SPMs, the forces on and resulting motions of SPMs are extremely complicated; the moorings and the tankers may each have six degrees of freedom in their motions. The characteristic frequencies of the

motions of each are an order of magnitude different owing to the tremendous difference in size and mass between the components of the mooring system and the tanker. Owen and Linfoot have developed simplified mathematical models of SPMs. They have been able to verify the amplitude of the motions predicted by their model (but not the frequency) by scale-model tests in the rather simple small-wave tank that was available to them in the past. Their principal problem was interference by waves reflected from the models and the sides of the tank. The larger, more complicated, and more precise wave tank, completed in 1977, does not suffer from this problem. It can simulate on a 1/100 scale an offshore system with a 100,000 ton tanker in 80 m depth of water. A nonpermeable beach is used where waves are absorbed by the shoaling action on the beach surface. There are 17 electromechanical computer-controlled "absorbing" flap wave generators that are capable of generating any type of sea or swell or combination that is desired, including independent cross seas at any desired angle and pre-determined wave spectra. Most of the remaining standing or reflected wave energy that has not been eliminated by the beaches is absorbed by the wave generators, using an ingenious computer-controlled feedback system. Each generator has a sensor that tells the computer the characteristics of the impinging standing or reflected waves. The computer then tells the flap of the generator when and how much to move to absorb the unwanted signals. Movements of the model ship are recorded by an overhead TV camera. In addition to using the tank for research and instruction, it may also be rented to oil company engineers to do their own model testing.

Another of Helliwell's group, Dr. Ian Grant, is in the final stages of constructing a 1.2 m × 2.4 m × 25 m combination wave tank and wind tunnel. Its wave generator is somewhat less sophisticated than the one in the 9 m × 9 m × 1 m tank. The closed-circuit wind tunnel over the wave tank will be able to generate winds over the water's surface from 1 to 10 m/sec. He plans to study wind-wave interaction, including wind-wave generation with both steady and gusting wind speeds.

Grant uses a Doppler-shift laser (*ESN* 33-7:296) to measure the particle motion within the waves as a function of phase and depth. A rotating grating is included in the arrangement so that direction as well as amplitude of particle velocity can be determined without ambiguity. Grant can also measure air velocity with this laser, after introducing smoke into the wind tunnel. From this he can tell how the wind circulates in the trough and how the wind profile over the waves is distorted during each phase of the waves. He has developed a sophisticated way of recording the Doppler laser shift at very high speed (10-μsec samples) so that he can study air and water velocity microstructure in great detail. The free-stream wind speed is measured with pitot-static tubes. Twin-wire resistive wave gauges on rigid supports measure changing height of the water surface.

The bottom center section of the long tank can be removed, giving a water depth of about 2 m. Here SPM systems, model tankers, or moored supply vessels can be tested in deeper water than that available in the 9 m × 9 m × 1 m tank. The effects of wind on any such system may also be studied.

Dr. P.P.G. Dyke, also of the Department of Offshore Engineering, is working with mathematical models of dynamic processes in shallow coastal waters. His doctoral research was on residual currents induced by tidal oscillations in shallow seas (see Zimmerman's work in *ESN* 33-7:296). These residual flows are often more important than the stronger oscillating tidal currents in the dispersal of pollutants from coastal outfalls. For this reason research on residual currents is receiving attention at most of the oceanographic laboratories (more than a dozen) that I have visited so far in Europe. Residual currents in shallow water are very difficult to measure (*ESN* 33-6:258) because they are normally more than an order of magnitude slower than the oscillating tidal currents and particle velocities associated with surface waves.

Large oil and gas terminals have been proposed for relatively wide estuaries such as the Firth of Forth in Scotland. It will be necessary to discharge pollutants, including large amounts of ballast water, from

these terminals into the estuaries. Most of the estuaries are stratified, with saltier water on the bottom underlying fresher water on the surface. In order to determine the best location for outfalls in wide stratified estuaries, Dyke has developed a mathematical model of tidally induced residual flow that takes into account the stratification and the effects of Coriolis force. In the absence of direct measurements of residual currents, Dyke's model can be used to estimate the preferred place to locate an outfall in a wide estuary.

Figure 1 shows the relative residual currents generated by Dyke's model for a wide stratified estuary in mid-latitudes. The actual magnitude of the currents will depend on the latitude, the shape and dimensions of the estuary, and the stratification. Figure 1a indicates that a surface outfall should be placed close to shore near the mouth of the estuary on the left hand side (when looking seaward down the estuary). Conversely (Figure 1b), a bottom outfall should be near the shore and the mouth of the estuary on the right hand side of the estuary.

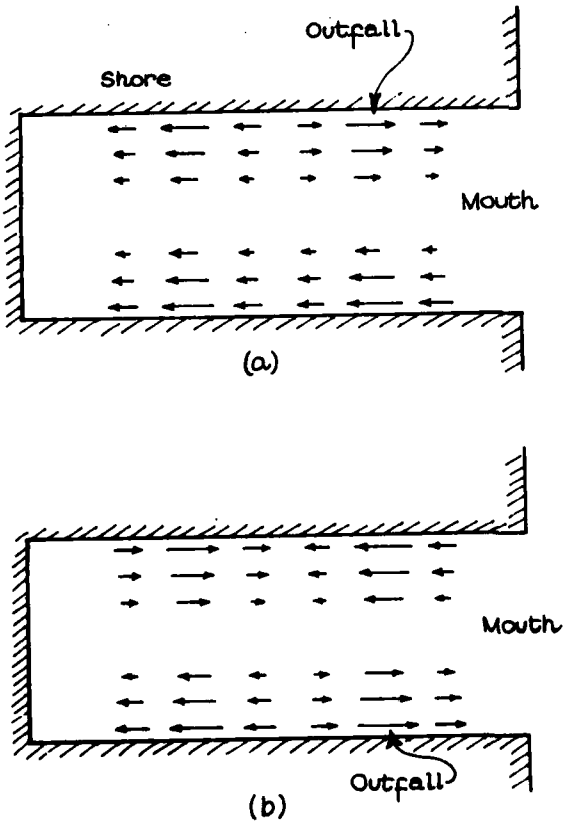


Figure 1

Since my visit, the Science Research Council has announced a research grant in excess of £1 million for a coordinated wide-ranging program of marine technology research to Heriot-Watt University.

One cannot help but catch the contagious air of enthusiasm which prevails in the offshore engineering programs at Heriot-Watt University. Most of the researchers I met were quite young and showed an unusual degree of *esprit de corps*. (Wayne V. Burt)

OPERATIONS RESEARCH

CARE IN SOCIETY—SWEDEN

Sweden has historically had very different social development from that in America. For example, there *are not* (*nor* have there ever been) trespass laws such as those in Anglo-Saxon jurisprudence; you are free to wander onto anyone's private property, and even to pick berries and mushrooms, or to camp—but to camp, for example, for one night only, and not within sight of the house. While Sweden's economy is still nominally capitalistic, they have an unparalled system of social security, with expenditure on social welfare equivalent to more than a quarter of their GNP. Withal, Sweden has developed from one of the world's most impoverished countries (hence the enormous Swedish emigration to the US in the 19th century) to one that in spite of its harsh climate and comparative paucity of raw materials has today one of the world's highest standards of living—higher in fact by most measures than in the US.

The Swedes appear well satisfied with this system; all the significant political parties wish to maintain these trends, although some wish to slow them down. Nonetheless, there must be causes for worry; simple ex-

trapolations show that in a few years no one will be producing anything in agriculture or industry and half of the Swedes will be fully occupied taking care of the other half. Obviously such extrapolations are ridiculous, but the Swedes are indeed worried about the future of their society, and in 1973 established a Secretariat for Futures Studies currently reporting to the Minister of Education and budgeted at about $1m/yr. Most of the work of the secretariat is carried on through projects. It has already completed projects entitled "Working Life in the Future," "Sweden and the World Society," "Resources and Raw Materials," and "Energy and Society." Underway at the present time are projects entitled "Sweden and the New International Economic Order," and "Care in Society." I visited the last-named at its offices in downtown Stockholm.

The project is headed by Dr. Mårten Lagergren, whose background is in operations research. He was at one time head of the Defence Studies Department at the FOA (see next article); many of Sweden's OR people appear to have come out of this kind of experience, including Lars Ingelstam, head of the Secretariat for Futures Studies. Lagergren received his PhD from the Univ. of Stockholm in mathematics and economics. After many years working on naval operations research he went to the Swedish Planning and Rationalization Institute for Health Services (SPRI), which he left in late 1977 to head up the Care in Society project when it was founded. He has been president of the Swedish Operational Research Society and in that capacity, in 1972, convened the first Nordic Operations Analysis Congress (NOAK), which has been meeting annually ever since (the 1979 meeting was in Oslo 24-25 Sept. 1979). He has also been active in the working group on health of EURO (the European Operational Research Societies see *ESN* 33-8:337). However, Care in Society is hardly a classical OR project. Lagergren has a staff of three professionals: one civil engineer, one sociologist, and one nurse!

Care, for the purposes of this project, is very broadly defined, to include care of children and of the elderly for example, but health care is paramount. They have performed some fascinating studies on health care. One of these shows that in 19 countries (15 European, Australia, Japan, US, and Canada) the per capita cost of health care is essentially independent of the way health care is organized (private or public) and financed (taxes, insurance, or out-of-pocket) and depends only on affluence; regression of health expenditure per capita on GDP (gross domestic product) per capita explains 90% of the variation.

Lagergren has also produced quantitative extrapolations of the type mentioned above, based on a simplified model connecting five variables—population, services, labor, costs, and employment. He admits that the outcomes of these projections look absurd, but points out that the outcomes of similar projections 25 years ago looking forward to today would have looked equally absurd, although they would have drastically underestimated the changes that have actually taken place. Some of the trends are startling; for example, the number of bed days per year per capita of in-patient care has been decreasing rapidly for all age groups other than the old, due to shorter length of stay, but increasing rapidly for the old due to a variety of medical as well as sociological reasons. The proportion of the old in the population is also increasing, and so Lagergren's model predicts that in 40 years almost 80% of the hospital beds will be occupied by people over 75 years of age. Again, the number of visits of patients by doctors outside of hospitals per year has been drastically decreasing. There could be many explanations for this decrease; for example, it is possible to conclude that this implies better care per visit. Nonetheless it represents a decrease in productivity, and, from the data, it seems hard not to project it as a continuing trend at the rate of at least 3%/yr.

Lagergren performed a number of classical OR studies while working for SPRI: an interactive budget simulation model, models of patient planning and assignment routines, models to determine the flow of patients and health personnel, and the like. He emphasizes that no single project has ever been completely implemented by the Swedish Health Organization; but his standards for what he would call "complete implementation" are extremely high. Swedish health care

is highly decentralized. By complete implementation he means that the OR studies should be successfully completed, successfully tested at the local level, accepted by the central authorities with recommendations for implementation at the local level in all other branches, and finally generally accepted at local levels. Even with the most successful projects, by the time this was completed the situation would doubtless have changed, so that implementation would have to be dynamic.

However, in Care in Society no such classical techniques are being used. They do a lot of scenario writing, project different alternatives, and try to determine the effects. They have some simple manual models of the health care sector, and hope to combine these with an elaborate econometric model that has been developed by the Ministry of Economy. Basically, Lagergren told me he is working now not as an operations researcher or even as a systems analyst, but as a project director of a futures study. He is planning a conference to tell people in Sweden about operations research in health, but the general state of OR in health services is not very well developed.

Lagergren is particularly concerned about Sweden's evolution into a "professional society" in which employment in industry, agriculture, and forestry goes down while employment in services goes up. Such an evolution has both good aspects and bad. Clearly the availability of professionals when one is suffering from appendicitis is highly desirable; on the other hand, children and the elderly lose something when they are taken out of the family and put into the hands of professionals to care for them. Finally there is the continually increasing expense of care in society, and Sweden already suffers under a nearly unbearable tax burden.

It is a sign of some hope that Sweden is indeed worrying about these problems and putting that worry in the hands of competent professionals like Mårten Lagergren. Since we appear to be following in many ways in the footsteps of the Swedes, it will surely be of interest to the US to read the final report of this project. (Robert E. Machol)

OPERATIONS RESEARCH IN THE SWEDISH DEFENCE DEPARTMENT

The FOA (there is doubtless an excellent reason why this is the abbreviation for Försvarets Forsknings-anstalt) or Research Institute of the Swedish National Defence is an organization of some 1500 people, 900 of whom are professionals, located near the center of the city of Stockholm. Organizationally it is an "authority" which reports not to the Department of Defence but directly to the government. My hosts stressed to me that it is not a "think tank" like Rand, but rather functionally a part of the Department of Defence. It consists of five divisions, one of which is Planning, Operations Research, and Systems Analysis, and within this division are several departments, one of which is Defence Studies. It is here that I talked to a number of people including the head of the department, Dr. Hans Elger.

Although Elger took his PhD in mathematics (from the Royal Institute of Technology), he takes a rather negative view of the application of quantitative methods to systems analysis. He told me that "philosophy is not a bad background," and that model building and computers had a bigger role in FOA many years ago than they do today. He attended the recent meeting of ORSA/TIMS in New Orleans and feels that the Americans are far too technique-oriented. He specifically admitted that FOA's work should not be compared with the norms of the scientific community as a price to be paid for being problem oriented. He also said "the most important contribution of our organization is the introduction of the long-term planning system."

Elger's people rely heavily on qualitative techniques, such as scenario writing, supplemented by some quantitive techniques, such as forecasting, for analyzing things like the strategic implications of technological development. They also have an economist working on defense industry problems and on such questions as how to plan military personnel requirements for the future by age groups. But most of their efforts tend to be qualitative in studies of such things as who can threaten Sweden in the future and how such threats

would be implemented, including nonmilitary (e.g. economic) threats.

Elger's department is divided into five groups of approximately four professionals each. While Defence Studies recruits and pays these people, their actual day-to-day work is in-house with the various staffs; this organizational concept was adopted many years ago by the Operations Evaluation Group of the US Navy, but has not otherwise been widely used in the US. It seems to work well in the Swedish military, and recommendations of Defence Studies appear to be given due consideration, not only in the staffs, but at the Joint Chiefs of Staff level.

I talked with Dr. Per Agrell, Deputy Director of Defence Studies, who took his doctorate in mathematical statistics at the Univ. of Gothenburg in 1967. He is still interested in statistics and is now working on a paper applying search theory to problems of estimation. Specifically, there exists a body of literature started by B.O. Koopman under the name of "search theory" (*ESN* 33-6:253) in which one seeks to allocate search effort so as to maximize some criterion function such as probability of detection or expected number of detections. The objects detected may be enemy submarines, or they may be faulty devices coming off a production line. Agrell applies this theory to the problem of estimating the parameters of a nonlinear function, using the sizes of the various samples as the measure of the effort to be allocated.

One of Agrell's principal interests is keeping the staff up to date academically, which is especially difficult because of the in-house assignment of staff members to various defense organization. He uses a number of conventional techniques, including seminars, courses, and the like. What intrigued me was that he also circulates papers containing summaries and impressions of what he sees and reads; as he described it, it reminded me very much of *European Scientific Notes*.

Agrell was formerly director of the Naval Research Section of Defense Studies. That position is now held by Lennart Lundh, who has an MS in mathematical statistics from the University of Lund and has also studied numerical analysis and data processing. He has been with FOA for ten years. This group does weapons systems studies. There is some quantitive background in these, but it does not dominate; the decision makers in the Swedish military are less receptive to the OR kind of thing than in the US, where many military officers have been given professional instruction in systems analysis at the graduate level.

As an example, Lundh told me about a study of defense against attack on Sweden by hostile naval forces, and in particular the question of whether Sweden should develop the capability of intercepting such forces at a considerable distance from the Swedish shore; that is, should there be an emphasis on Navy and Air Force facilities at the expense of coastal defenses and army? The answer from their war gaming apparently was "no," although they appear now to be reopening the question.

Lundh talked about the problem of comparing different force systems in realistic scenarios. One of their criteria is the cost to the aggressor. For example, mines are very important for the defense of Sweden. While such mines may not actually sink aggressor ships, they significantly modify aggressor behavior. That is, even if the aggressor does not sail through the mine field, if he is forced to sail around it, that has a significant effect on the outcome of the battle. The question is how to measure the aggressor's behavior and its importance for military effectiveness.

Lundh's group prepares a "prospective plan" for 15 years ahead, used in making the rolling plan submitted to parliament every five years by the Joint Chiefs of Staff, at which time parliament makes long-term budget decisions. Lundh assured me that, because of this emphasis on long-term integrated budgeting, there is more consideration in Sweden than in the US of the relation of one system to another, and hence more room for effective operations research/systems analysis. While the studies that Lundh and his group make are obviously filtered at many levels before they get to parliament, Lundh does have the satisfaction of seeing his work actually influence the budgetary process.

I talked with Dr. Brita Schwarz, a fascinating woman who has been with FOA on and off for 20 years. She took her doctorate in math at the Univ. of Stockholm, and originally thought of herself as an operations researcher. Then she discovered long-range planning and, in the early 1960s, the work being done at Rand Corporation, and thought of herself as a systems analyst with interest in planning and decision-making processes. In 1966 she became head of the Defence Studies group at FOA, but left and went to the OECD in Paris where she did program-planning-budgeting studies, strategic planning, and other things for the education group in OECD. Returning to FOA, she became an advisor to the military minister on nonmilitary defense, and was involved in attempts to export the Defence Department's type of planning systems to nondefense aspects of the government. Since 1976 she has been head of the policy planning unit of the FOA, but in an unusual administrative situation where she sits physically in the Stockholm School of Economics as head of a group of four professionals whose funding comes exclusively from FOA.

The first major project of this policy planning group was on transportation. *Long-range planning* studies of defense had proved useful for R&D and hardware studies in the civilian sector, and it was thought that studies of military transport might similarly be useful. They made a complete study including roads, rails, pipelines, and the like, but Schwarz did not feel that this was a particularly successful study. They are now starting an energy project for which they are more hopeful. They are trying to get more realism into energy policy, and one of the principal lines of effort is through the MARKAL model, which they obtained from Brookhaven via the International Energy Agency. This model, which was described in *ESN* 33-10:411, has been modified to describe the Swedish National economy. It is basically an optimization model; Schwarz would have preferred a simulation model, but this seems to work well. One can, for example, change the objective function to minimize total cost, imports of oil, or the like.

With her present position at the School of Economics, Schwarz would like to introduce a new type of PhD program in which students would spend a year or two outside of the school working on a real problem as part of their thesis effort. It is not clear how this will work out. "At any rate," she told me, "I have a tenured job at FOA if things go badly."

In many ways Sweden is very different than America. They have, for example, a socialistic economy which in spite of some strains appears to be working extraordinarily well. They are, by some measures, the most affluent country in the world in spite of a harsh environment and minimal natural resources. Similarly, their methods of defense analysis seem to be very different indeed from our own. As nearly as I could tell, they seem to be working very effectively in Sweden. (Robert E. Machol)

OPTICAL PHYSICS

INJECTION LASERS—RESEARCH TO PRODUCT

The number and importance of the roles played by semiconductor injection lasers are on the upswing, hardly a new story in the laser world. The use of injection lasers as the radiation source in optical fiber communication systems, very long-play disk systems, and in illuminators and training aids (primarily military) is receiving considerable attention by R&D laboratories. International Telephone & Telegraph's (ITT's) "thing" is communication, and having realized the potential market for optical fiber communication systems, they have developed a research base in the two key ingredient areas, injection lasers and optical fibers. In the UK, ITT's research base, developed at Standard Telecommunication Laboratories, Ltd. (STL), Harlow, led to the development of product capability at their Components Group, Paignton. (At present, ITT is the only commercial source of injection lasers in the UK.) The objective of this article is to report on recent visits to the facilities at Harlow and Paignton and in so doing to give a flavor of their injection laser research, the research-to-product transition process, and their laser product line.

On 10 July 1979, I was hosted by STL's Chief Research Engineer,

C.H.L. Goodman. After having an interesting discussion on research philosophy, I was briefed by group leaders on current work in electro-optics (EO) and taken on a tour through a number of EO laboratories. As injection laser research was one of many subjects reviewed that day and as I wanted to discuss this topic in considerable detail, the injection-laser group was revisited some months later. Before presenting an overview of the injection-laser research efforts at STL, a few of the other EO programs will be mentioned. A number of integrated optics (IO) and surface acoustic-wave (SAW) projects were reviewed. One IO project, in which prism coupling is used to both inject and extract the optical signal, makes use of a SAW/light interaction in $LiNbO_3$. This effort is being conducted in conjunction with the UK university community. Another project involves the development of a memory correlator that uses a SAW delay line on a semiconductor (silicon or GaAs) and the interaction of SAW with diodes on the same semiconductor. STL is one of several laboratories in the UK involved in research in the area of surface-skimming bulk waves (SSBW) (ONRL R-13-77, limited distribution). SSBW are generated and detected by conventional interdigital SAW transducers and, as the name implies, these waves propagate in the bulk material very close to the surface. The velocity and frequency of SSBW are ~60% higher than the SAW generated simultaneously by the same transducer. Making use of SSBW is one way to beat the upper-frequency limit set by photolithographic processes. Advantages of using SSBW (other than their higher frequency) include increased temperature stability and their protection from the environment. STL has realized a remarkably low insertion loss of 3 dB for SSBW.

The 30-member semiconductor injection laser (IL) group, led by Peter R. Selway, is involved in at least 5 research projects. The growth and characterization of laser materials by means of the chemical vapor deposition (CVD) process is one of these projects. Among the potential advantages of IL materials grown by the CVD process over those grown by liquid-phase epitaxy (LPE) are: improved uniformity and reproducibility, larger area defect-free crystals, and growth by large-scale automation. Because of the high potential for CVD materials, STL has recently increased the size of the CVD effort from 3 to 5 persons. A complete listing of the characteristics of IL produced at STL from CVD grown materials was presented recently (*ESN* 33-7:301). In a recent article, co-authored by the leader of the CVD effort, E.J. Thrush, the details of a CVD grown double heterostructure wafer along with cw reliability data on lasers produced from this wafer are presented [*Elect. Lett.* 15, 666 (1979)].

The wavelength dependence of the attenuation in silica-based fibers has more than one minimum. Attenuation measurements made at STL on an in-house-produced 2.127-km multimode fiber (see Figure 1) reveal three minima less than 1 dB/km; two of modest width centered approximately at 1.2 μm and 1.3 μm, and a third broader minimum centered at 1.6 μm. To take advantage of the low attenuation at these wavelengths, STL has a 10-person team working on the growth, characterization, and optimization of materials from which IL emitting in the 1.05 to 1.35 μm and 1.5 to 1.7 μm bands are fabricated.

This long-wavelength laser work is based on the (Ga,In)(As,P)/InP materials system, and the double-heterostructure wafers are grown by the LPE process. In the 1.05 to 1.35 μm band, both broad contact (500 μm by 100 μm) and stripe-geometry oxide-insulated (20 μm by 300 μm) lasers were fabricated and characterized.

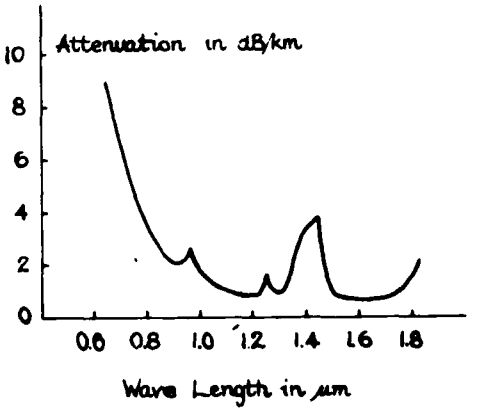


Figure 1. Attenuation vs wavelength for "typical" silica-based fiber.

Broad contact lasers emitting at 1.3 μm and having an active region thickness of 0.2 μm had threshold current densities as low as 900 A/cm² when operated in the pulsed mode (200 nsec). Stripe-geometry lasers operating in single longitudinal mode at 1.3 μm had cw thresholds as low as 180 mA. Life testing of new types of lasers is obviously very important, and preliminary data based on 550 hours of cw operation at 20°C with output powers between 2 and 3 mW indicate no change in threshold current.

Encouraging results have been obtained recently in STL's development of ILs operating in that part of the spectrum which corresponds to the lowest fiber absorption, 1.5 to 1.7 μm. Data are available for broad contact devices (500 μm × 100 μm) with an active layer thickness of 0.6 μm. The characteristics of these lasers, emitting at 1.55 μm, were determined with the devices operated in the pulsed mode (200 nsec) at a 1 kHz repetition rate. An 11% external quantum efficiency was realized when the light emitted from both resonator facets was accounted for, and perhaps more interesting was the observation of the lowest normalized threshold current density recorded to date (3.54 kA/cm²/μm) in any IL operated at this wavelength. This lowest value can be compared with the average for ten randomly selected devices of 4.23 kA/cm²/μm, and the lowest previously reported value of 4.5 kA/cm²/μm [based on (Ga,In) as grown by the molecular beam epitaxy process].

Even though the research-to-product transition process followed by STL and the Components Group is logical, and most likely not unique, a brief description of the author's perception of this process is presented. After the research relevant to a particular laser device or group of devices was completed, and the decisions regarding which devices to produce and market were made, personnel from the Components Group spent several days at STL in over-the-shoulder study of the crystal growth and device fabrication/characterization procedures. After duplicate (or improved) fabrication facilities were established at Paignton, personnel from STL worked side-by-side with the products group to 'work the bugs' out of the 'duplicate' facilities and procedures. To this form of coaching was added the innovativeness and persistence of the Components Group personnel and follow-up consulting as needed from STL. The remainder of this article contains a discussion of the production processes, and a description of their off-the-shelf products.

When an IL is purchased, one expects it to have the much-advertised characteristics of other semiconductor devices, i.e., efficiency, performance stability, and long life. The realization of these characteristics in a marketable product requires a major post-research effort in process control (including materials), device characterization ‡ process control "feedback", and quality assurance. To meet the tight dimensional tolerance, low stress, heat sinking, and electrical contacting requirements of ILs, the Components Group in Paignton has both capitalized on STL's experience (as mentioned above) and developed additional procedures as needed. When stringent environmental requirements including wide operating temperature and humidity ranges, and a high degree of vibration and shock immunity are added to the above requirements, quality assurance at each fabrication step is of utmost importance.

Consider briefly the dicing process, one of eight major processes. The stripes of laser material resulting from the cleaving process are cut (diced) to the desired width. For broad contact ILs, the cut width determines the width of the active region, and for some applications, this dimension is closely specified. Ring modes detract from performance, and their supression is accomplished by the roughened nature of the cut sides. To minimize cut damage and the resulting risk of crystal defect propagation through the active region, and to achieve adequate ring-mode suppression, very strict control must be maintained over the abrasives, cutting-wheel quality, cutting speed, etc.

A wide variety of ILs are available from ITT. Currently their ILs include: single heterostructure (905 nm, pulsed); broad-contact double heterostructure (850 nm, pulsed); stripe-geometry double heterostructure (830 or 850 nm, cw); single-mode stripe-geometry double heterostructure (830 nm, cw); high-power stripe-geometry double heterostructure

(835 nm, cw); single-heterostructure multichip stacks (2 or 3 diodes) and linear arrays (6, 12, — or 40 diodes) (905 nm, pulsed); and fiber-coupled arrays with up to 84 diodes (905 nm, pulsed). The range of output radiant power available is from <1 mW cw from the stripe-geometry double-heterostructure laser to >500 W peak power from the largest fiber-coupled array. In addition, high frequency ILs with a rear-facet monitoring beam, cw ILs with an integral monitor photodetector, and high-radiance light-emitting diodes (820 or 850 nm) are available. It should be pointed out that there is a choice of each type of device listed, and as research and the research-to-product process are far from complete, this list of products may be outdated as of the date of this issue.

I would like to close this article with a description of the newest member of ITT's laser family. This device is a narrow-stripe-geometry, double-heterostructure laser, the conducting stripe being only 3 μm wide. In the 'standard' 20 μm wide stripe laser, the optical confinement is largely caused by stress induced gradients in the refractive index that occur along the edges of the stripe. (This effect presumably is a result of the stress field in the silica insulating layer.) In contrast, the silica insulating layer used in the narrow-stripe lasers is much thinner, and the light is guided by the shape of the injected carrier concentration profile beneath the contacts (referred to as optical gain guiding). Because of the dielectric anti-waveguiding that occurs in the active region, the output width at the front facet is 8 to 10 μm, considerably wider than the stripe. Because the stripe contact area is small, the threshold currents are quite low, typically 70 to 100 mA. The use of this new laser in optical communication systems is attractive for two reasons. First, since the output above threshold exhibits very good linearity, there is a serious possibility of analogue optical communication techniques being used. Second, because of the multilongitudinal mode output (typically 5 modes between the envelop's 3 dB points), resulting from the low quality factor of the optical resonator, the problems associated with modal noise are greatly reduced.

Not only can one expect an expanded laser line from ITT, but as a result of research that I am aware of elsewhere in the UK, at least one other commercial source of ILs should become available within the next year or two. (Richard S. Hughes)

NEWS & NOTES

COMMUNICATION AID FOR DEEP SEA DIVERS AT EDINBURGH

To the deep sea diver, working in an isolated potentially threatening environment, an effective communication system with his ship or base is a vital factor to his safety and working efficiency. At present, the divers' communications are made via the cable, or line, which physically attaches them or their diving bell to the mother craft. But as the accident last summer in the North Sea demonstrated, this life and communications line is sufficiently vulnerable to result in fatalities from time to time.

What is less generally known about divers' communications is that the mixture of helium and oxygen gases, which they are forced to breathe in order to avoid the toxic and narcotic problems of breathing high-pressure air at depth, also severely distorts their speech. This means that without special equipment on the control ship, neither surface personnel nor another diver, even if working right next to the first, can make much sense of what is being said.

Until recently, such unscramblers have needed to be the size of a TV set, mounted on the divers' control ship. During the past year, using a design conceived by Dr. Mervyn Jack of the Univ. of Edinburgh, the Wolfson Microelectronics Institute of that Univer sity has developed a portable battery-powered unscrambler the size of a small transistor radio. The new unit is based on the use of silicon charge-coupled devices, well-known for modern signal processing applications. Jack now looks forward to reducing the size of the unit even further, to matchbox size, by incorporating most of its functions in a single silicon chip.

It is hoped that the miniaturization, which has been accomplished, will form the cornerstone of a safer and more efficient communications system for underwater work in the North Sea oilfields and around the world. The developer of the unit, the University of Edinburgh's Wolfson Microelectronics Institute, directed by Dr. A.D. Milne, is allied to and located adjacent to the University's Department of Electrical Engineering. The Institute was established in 1969 with a "pump-priming" grant of £130,700 from the Wolfson Foundation and is now a self-funded research and development organization covering microelectronics design and instrumentation and systems development, with an expanding emphasis on applying microprocessors to new products and industrial processes. It also undertakes industrial training at the engineering-staff level.

As part of a major cooperative University-local authority initiative, a new Microprocessor Development Laboratory is in the process of being established at the Institute with the financial backing of Lothian Regional Council, to develop further the services offered by the Institute to industry and commerce. As part of the same initiative, a new Chair of Microelectronics is to be established at the University. (Irving Kaufman)

NEWS

THE QUEEN'S NEW YEAR HONOURS LIST

The following persons in UK universities and/or science and technology have been given awards in the 1980 New Year Honours List:

Knights Bachelor (KB): Prof. James W.L. Beament, Chairman, Natural Environment Research Council; Prof. Max Beloff, Principal, Univ. College at Buckingham; John Rogers Ellis, General Physician and Dean, London Hospital Medical College, who is also editor of the *British Journal of Medical Education*. Order of the Bath (KCB): Brian David Hayes, Permanent Secretary, Ministry of Agriculture, Fisheries and Food. Order of the British Empire (CBE): J. Black, Prof. of Engineering, Bath Univ.; W.E. Burcham, Oliver Lodge Prof. of Physics, Birmingham Univ.; T.E.H. Williams, Prof. of Civil Engineering, Southampton Univ. Order of the British Empire (OBE): D.E. Adamson, Principal, MOD; P.T. Grant, Dir., Inst. of Marine Biochemistry, Natural Env. Res. Council.

Other Awards:

Sir Fredrick Dainton, president elect of the British Assoc. for the Advancement of Science has been awarded an honorary degree of DSc by Salford Univ.

The new director of the Royal United Services Inst. for Defence Studies is Rear-Admiral Edward Gueritz (ret.). Since retiring from the Royal Navy in 1973, he has been commandant of the Joint Warfare Est. at Old Sarum, Wiltshire.

The Charles Leopold Mayer Prize, the most important prize of the Academie des Sciences, Institut de France, has been awarded jointly to Prof. Sir David Phillips, FRS, of Oxford Univ., and Prof. David Blow, FRS, Imperial College of Science and Technology, London. The award was made "to honour not only a powerful approach to a better understanding of the structure-functions relationships in the field of biological molecules but also two of the most brilliant representatives of the English School of Crystallography."

The European Physical Society has awarded the 1979 Hewlett-Packard Europhysics Prize to five individuals. The award of 20,000 Swiss francs is shared by Eric A. Ash (Univ. College, London Univ.), Jeffrey H. Collins (Univ. of Edinburgh), Yuri V. Gulaev (Inst. of Radio Engineering, Moscow), Kjell A. Ingebrigtsen (Norwegian Inst. of Technology, Trondheim); and Edward G.S. Paige (Dept. of Engineering Science, Oxford Univ.). This year's prize was presented for contributions to the understanding of the interaction between surface acoustic waves and electrons, and for the practical applications of these interactions effects to a new range of devices of particular importance in information handling.

Prof. E.A.V. Ebsworth, who holds the Crum Brown Chair of Chemistry at the Univ. of Edinburgh, has been named 1980 recipient of the American Chemical Society's Frederick Stanley Kipping Award in Organosilicon Chemistry sponsored by the Dow Corning Corp. The announcement of the $2,000 award was made during the Society's recent annual meeting in Washington and will be presented at the Society's meeting next March in Houston, Texas. Ebsworth is being honored for his outstanding contribution to the field, particularly his preparation of novel organosilicon compounds. His ability to combine chemical intuition, synthetic capability, and skilled measurements have led to a greater understanding of silicon chemistry, a statement issued by the Society said. The Kipping Award was established in 1960 to recognize distinguished achievement in research in organosilicon chemistry and, by such e example, to stimulate the creativity of others toward advancement in this field of chemistry.

PERSONAL

The Science Research Council has just announced that Sir Bernard Lovell, the doyen of British radioastronomy, is to retire in October 1981. His replacement is to be Prof. Graham Smith, the present director of the Royal Greenwich Observatory. Lovell, who worked on radar projects during WWII, became the world's first professor of radioastronomy in 1951. The next year he managed to raise sufficient money to begin work on constructing a giant steerable radar dish at Jodrell Bank and in 1957 the project was completed. In 1962 he was given a knighthood.

ONRL STAFF CHANGES

Just after Christmas we said farewell to our Chief Scientist, Dr. Herbert Solomon, who had been with us from January 1978 to December 1979. Solomon returned to the Statistics Department of Stanford Univ., CA. We welcome aboard Dr. Fred E. Saalfeld from the Chemistry Division of the Naval Research Laboratory in Washington, D.C. as our Chief Scientist until July 1980. We said farewell also to Dr. Irwin M. Freundlich, who has returned to his position as Professor and Chief of Diagnostic Radiology at the Univ. of Arizona in Tucson. We welcome also our new administrative Editor, Mr. Donald J. Peters, who is from the Defense Logistics Agency.

ERRATA

The Chief of the Biology Section of the Laboratorio per la Corrosione Marina dei Metalli in Genova, Italy is Dr. Sebastiano Geraci and not Giulio Relini as reported in *ESN* 33-8:363.